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The Journal of The Royal Aeronautical Society

With which is incorporated The Institution of Aeronautical Engineers

Edited for the Council by Capt. J. LAURENCE PRITCHARD, Hon. Fellow

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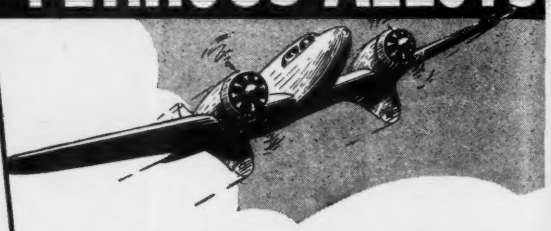

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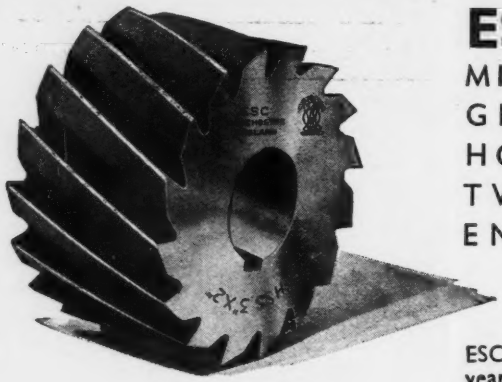

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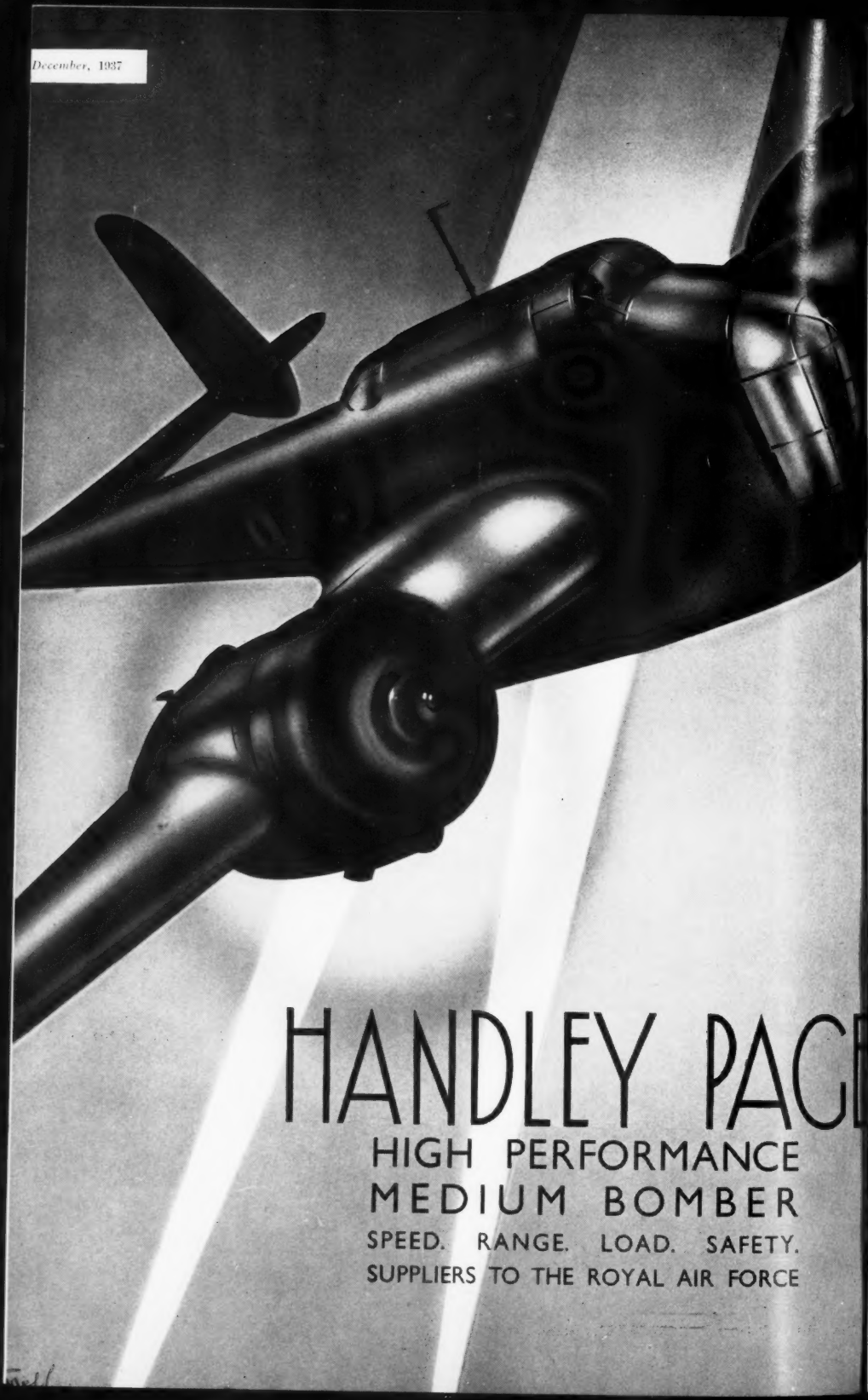
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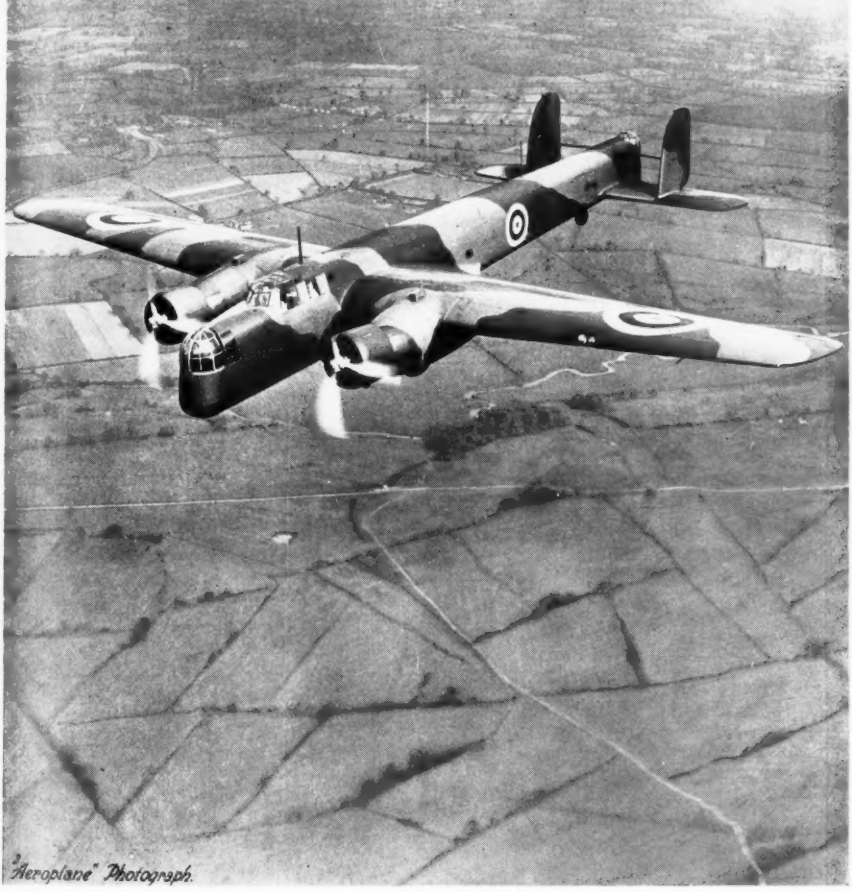

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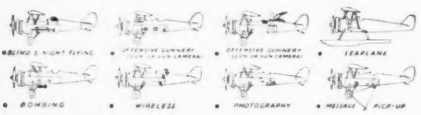

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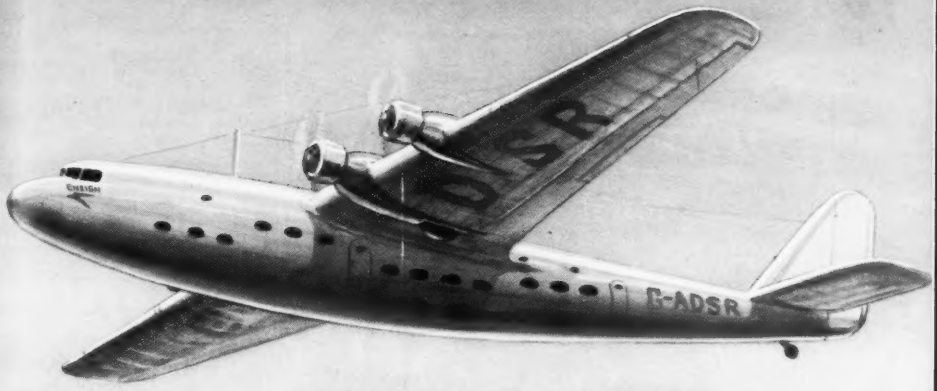

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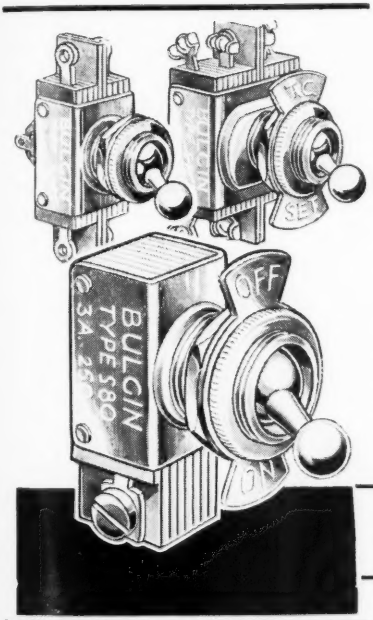

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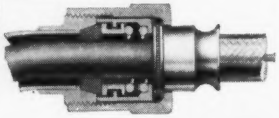

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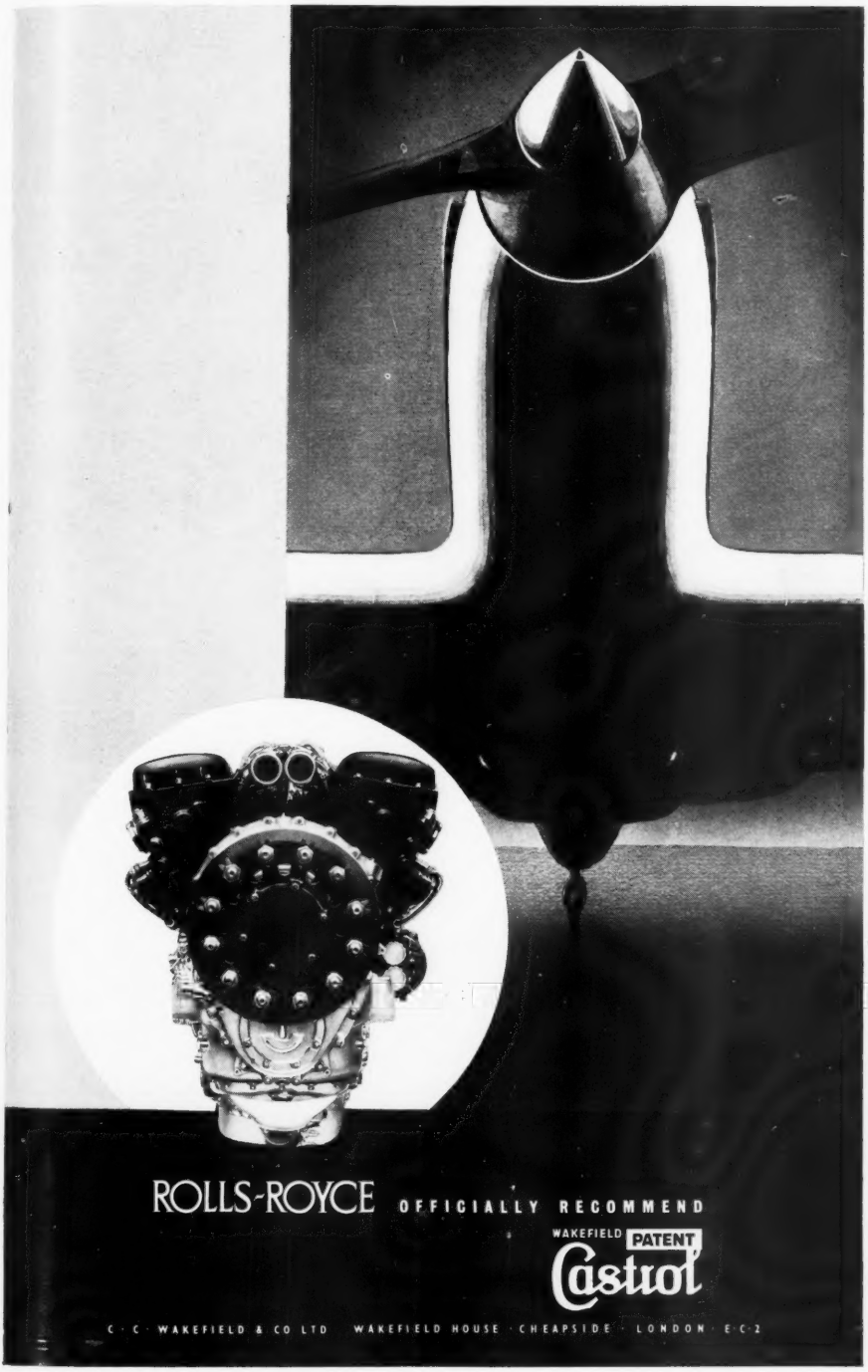
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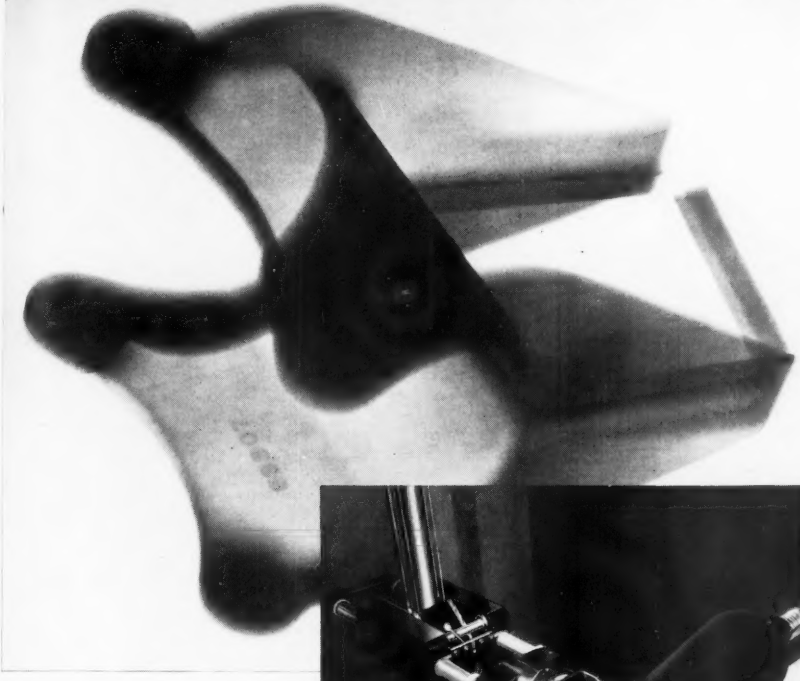

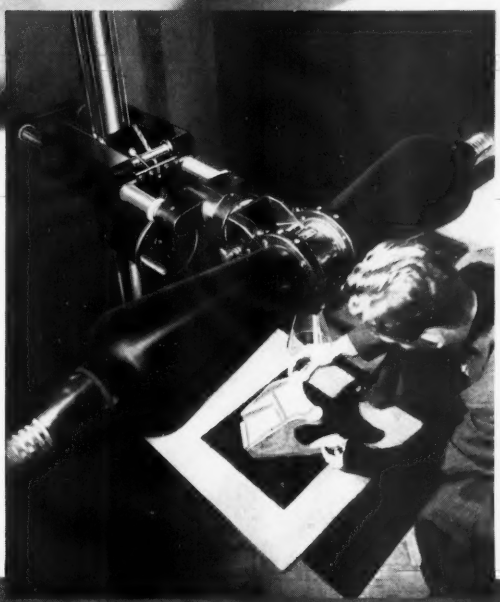

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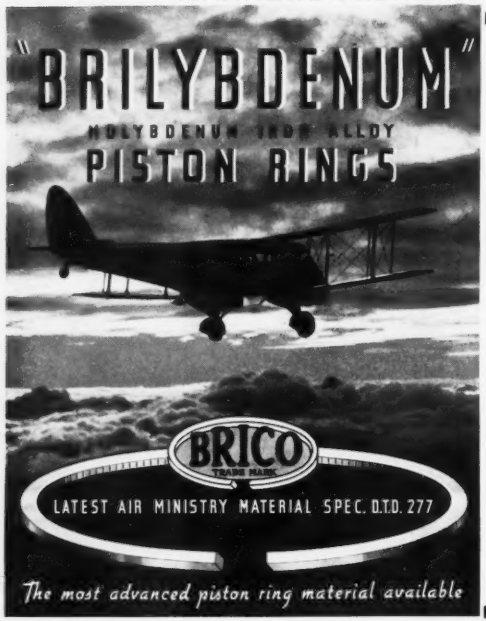

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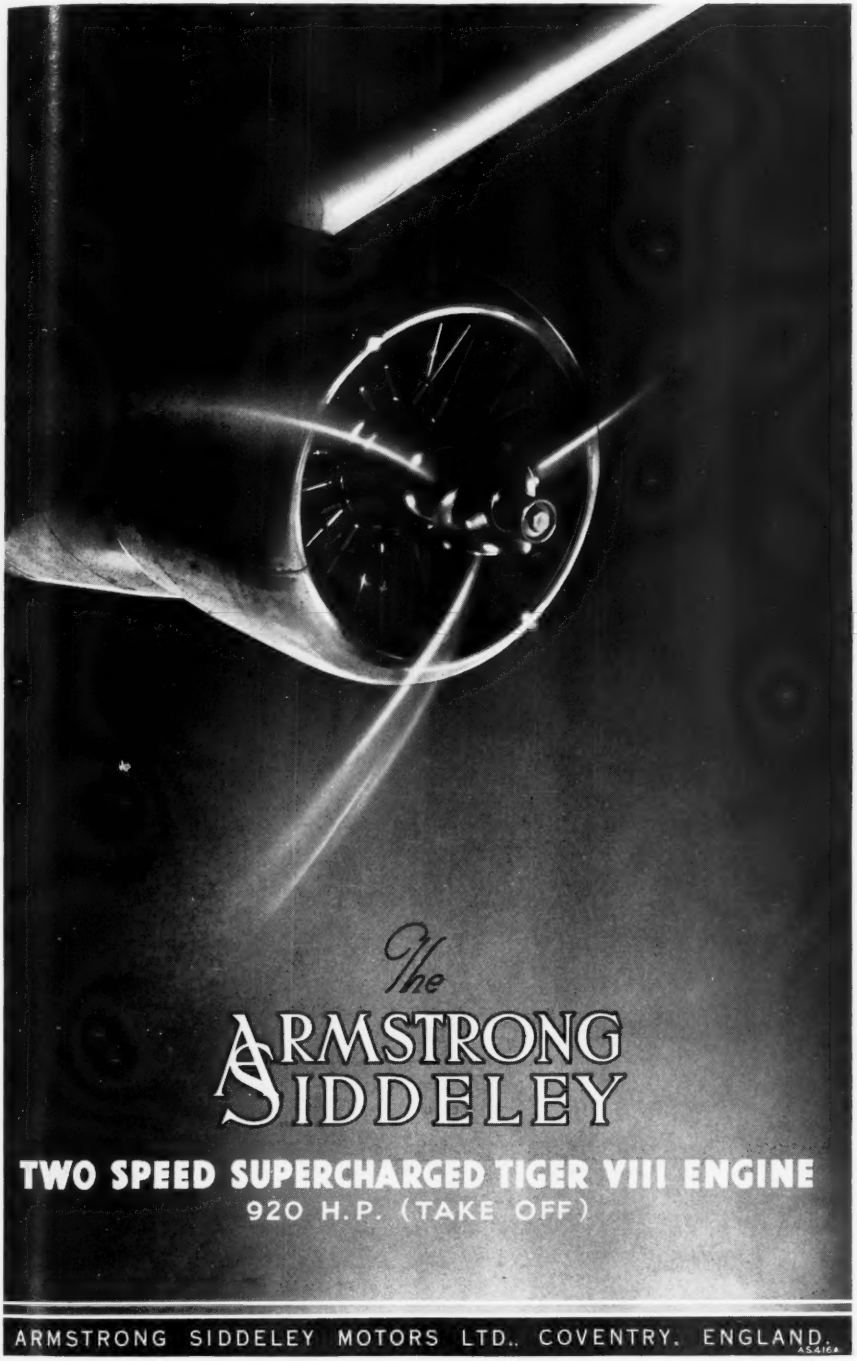
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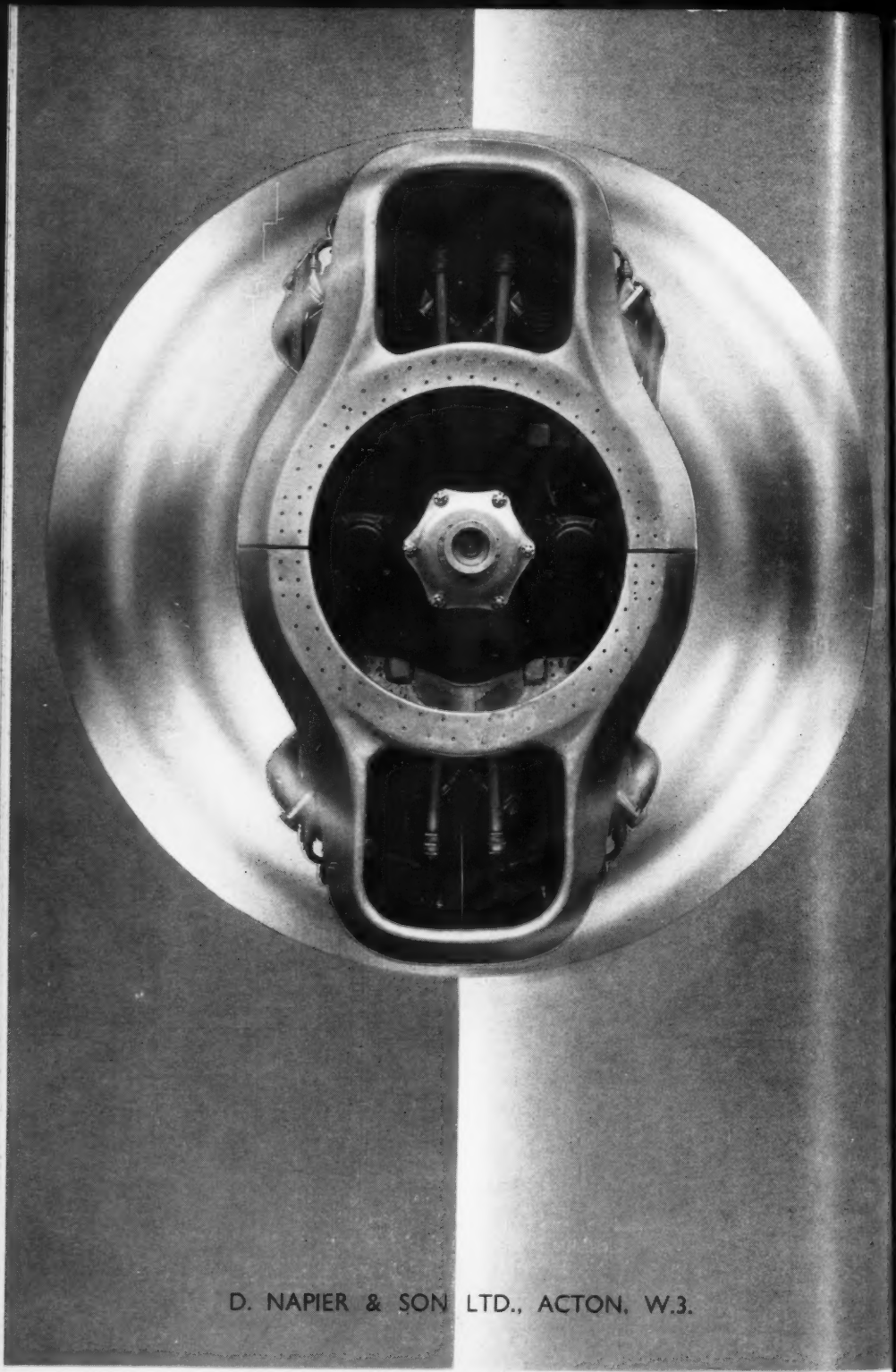

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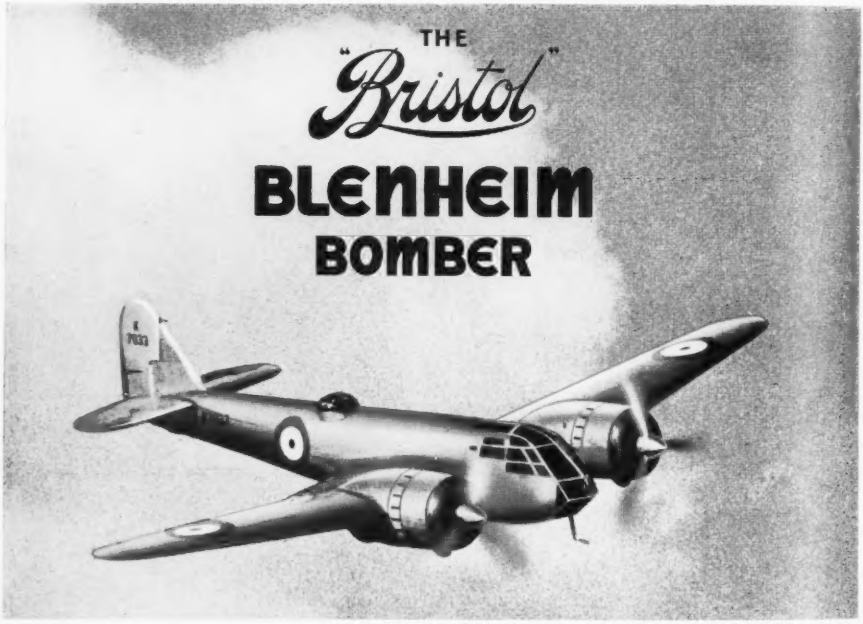

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The 622nd Lecture read before the Royal Aeronautical Society since its foundation on January 12th, 1866.

PROCEEDINGS.

A meeting of the Royal Aeronautical Society was held in the Lecture Hall of the Institution of Electrical Engineers, Victoria Embankment, on Monday, April 26th, 1937, when the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S., gave his Presidential Address.

The Work of the Society.

The President, before proceeding to deliver his Address from the chair, said that it was appropriate at that meeting to give some account to the members of the stewardship of the officers and Council. To borrow what is sometimes said on other occasions their relations with "foreign powers" continued to be friendly. The particular "power" with whom they had most need to be friendly was, of course, the Air Ministry. The Ministry assisted the Society financially, and had done so for the last ten years or thereabouts, and the Society was ready at any time to give the Ministry the best of its advice on any question remitted to it. On more than one occasion when difficult matters had been under discussion in the Aeronautical Research Committee, it had seemed good to that Committee and to the Air Ministry that a wider field of discussion should be available, and accordingly the subject had been brought before a meeting of the Society.

There was a time, about 13 years ago, when the then Organisation of Scientific Research did not commend itself to the Society's Council, and as might be seen from the printed *Proceedings*, a deputation waited on the then Secretary of State for Air urging that certain things needed to be done. The Secretary of State and his advisers were it seems convinced and they proceeded to do what was recommended. A new Organisation for Scientific Research was created at the Air Ministry, and the arrangements under which it worked were very close indeed to the actual recommendations put forward by the deputation from the Society. At present there was no need for the Society to make any representations of that kind. It had obtained what it desired. At all times the Society was ready to act as watch-dog and to take action on behalf of the Society and its members if it seemed desirable that something needed to be done.

The President then turned to the progress of the Society, and by means of a wall diagram showed the growth in membership since the foundation of the Society in 1866. During the last ten years the membership had doubled, and the rate of growth was rising so steeply that it was difficult on the diagram to show how steep the recent increase had been. During 1936 the steepness of the growth curve exceeded all previous steepnesses, and in the present year there was every indication that that tendency would be at least maintained. As far, therefore, as the size of the Society was concerned, there was every reason to be satisfied with what had happened.

Moreover, the growth was reflected in the numbers attending the meetings. The Society had been accustomed to meet at the Royal Society of Arts, and on some occasions during the last session the small hall there had been not nearly large enough to accommodate those who wished to attend, and many had remained standing throughout the proceedings. It was hoped in the next session to make arrangements for a larger theatre, probably the one in which the present meeting was being held.

Something must be said about finance. During the present session a munificent gift had been made to the Society by Mr. Fairey and Mr. Handley Page, who between them had given a sum of over £5,000 spread in instalments over seven years. The Council had many schemes in their mind for the enlargement of the activities of the Society, but a good many of them required finance, and therefore the Council had decided that a strengthening of the financial position, even apart from this £5,000 gift, was necessary. After all, the Society's reserve funds only amounted to between £10,000 and £15,000, which was small when compared with many scientific and engineering societies. He was glad to be able to report as a result of these further efforts that the Society had received deeds of gift from benefactors and well-wishers of the Society to a total of over £20,000, in addition to the figures which he had just mentioned. These deeds of gift provided for payment over a period of seven years. If he did not now mention the names of those who were their benefactors, it was because the Council wished to announce the names at what they considered the right moment, and because the list was still open. It would be understood that all this had an important bearing upon the home of the Society; the lease of the present premises was approaching its end, and the Council was very busy looking for fresh accommodation and some negotiations of a preliminary character were already in hand.

If one looked at the subjects of discussion during the last twelve months it was remarkable how very comprehensive they were. They surveyed new kinds of materials from new plastics right away to new types of motor fuel, and the subjects ranged from aerodynamic theory to the economics of air line operation. The Council felt very grateful to the lecturers on these occasions for their contributions.

PRESENTATION OF AWARDS.

The President then presented the medals and other awards of the Society to such of the recipients as were present. He said that the Society's Gold Medal, the highest award within the power of the Society to bestow had been awarded posthumously to the late Senor J. de la Cierva for his work on the development of the autogiro. The Gold Medal was first awarded to the Wright Brothers in 1909, and the names of the Gold Medallists were sufficient indication of the care with which this award was bestowed. Senor de la Cierva had addressed the Society on many occasions and received previous awards at its hands. He was held by his British friends in very high esteem and it was a very sad day when the aeronautical world heard of its loss. The tribute that he would like to pay to his memory was that he succeeded in producing a rotary wing machine that really flew and which, with many millions of miles to its credit, showed a fatality rate well below that of any other flying machine. There was present that evening Air-Commodore J. G. Weir, of the Cierva Autogiro Company, with which the late Senor was associated, and he would ask him to receive the Gold Medal on his behalf.

The Silver Medal was awarded at the discretion of the Council for some advance in aeronautical design. This year the Council had awarded two medals to Messrs. Meredith and Cook for their work on the automatic pilot. He understood Mr. Meredith could not be present and he would ask Mr. Cook to receive the medals on his own behalf and that of his colleague.

The British Gold Medal for Aeronautics was awarded by a special committee on which were represented the Society, the Royal Aero Club, and the Air League of the British Empire, under the chairmanship of Lord Amulree. The Council put forward their recommendation, which was endorsed by the Amulree Committee and he was therefore able to say that the medal had been awarded unanimously to Mr. Arthur Gouge, the distinguished designer of the Empire flying boats. He would ask Mr. Gouge to come forward to receive the medal.

The Simms Gold Medal was awarded for the best paper read before the Society in any one year concerning any science allied to aeronautics, and the Council had decided to award this year two medals, namely, to Dr. Gough and Mr. Wood for their paper on the structure of materials.

The Taylor Gold Medal for the most valuable paper submitted or read during the previous session had been awarded to Dr. G. P. Douglas for his paper on cooling problems, with particular reference to the work on the 24ft. tunnel at Farnborough.

The Edward Busk Memorial Prize was awarded for the best paper received by the Society on some subject of a technical nature, and this had been awarded to Mr. G. H. Dowty for his paper on retractable undercarriages.

The Pilcher Memorial Prize for the best paper by a student of the Society had been awarded to Mr. H. Leadermann for his paper on the fundamentals of boundary layer theory, with some applications to aircraft.

The awards were presented to the various recipients amid applause.

THE NATURAL LIMITS TO HUMAN FLIGHT

By H. E. Wimperis, Esq., C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S.

Introductory

The more I think about the subject chosen for this Address, the rasher does it seem. To proclaim limits to human flight is to do two things. To say what can be done, and to suggest what cannot. Now, though there may be little rashness in the one, there is much in the other. If I say that such and such a thing can be done and someone in the distant years points out that actually it has not been done, my shade has the easy reply that achievement requires effort and that my critics should use their brains.

But if I suggest that certain boundaries cannot be crossed, what fun for the coming race of engineers who cross them (if they do), than to poke fun at the memory of your lecturer to-night! And when I use the word flight I mean flying with wings and not the flight of a projectile.

It must be rash since wise men have diligently avoided such issues. Can one think of any engineer who has endeavoured to lay down for all time, what is the height of the highest skyscraper that can be built, or the longest bridge there can ever be thrown across a river, or the fastest motor car that the world will see? Again, does any ship builder dare specify a natural limit to the size of future ships or to the power of the engines they will carry?

Why in the field of aeronautics is this rashness found? It must, I submit, either be because the subject is so well knit to its scientific foundations that prophecy is tempting, or else, I tremble to say it, that the impetuous youthfulness of aeronautics blows caution to the winds. But if impetuosity be the key to the answer, I urge that by assembling this row of aeronautical ninepins, I encourage the resourcefulness of coming generations by providing them with the zest of knocking them down. And that, I think, is worth doing.

The globe on which we live is a nearly spherical ball 8,000 miles across. Its highest mountain, like its deepest sea, is about 5 miles from the surface. Let us make a model. We take in our hands an eight inch globe to represent the earth and show on it all mountains and all seas. The noblest mountain will project but one two hundredth of an inch, and the greatest sea be a depression of no more. In handling such a globe, it would be difficult even to feel the roughness of the mountains or to detect the dampness of the ocean. Still more surprising is it, that if the Bristol aeroplane were actually flying through the atmosphere at the ceiling of its record breaking height, it would only just be possible to squeeze under it a sheet of ordinary writing paper!

This shows the scale of things in true proportion. We are confined to a very thin shell in which to move and have our being, and this is the first of nature's bounds to the limits of human flight. If ever we are to hatch out from our shell, we must discover some lifting power which does not require an atmosphere.

It is easy to forget that our present attainments in human flight have all grown from the endeavours of a single generation. Our immediate predecessors in the air followed a much more leisurely course. Professor Julian Huxley* writes of bird evolution, "One thing at least is certain and significant; whereas in the general stock of mammals, progress was being made and new and specialised lines budded out up till a mere five or ten million years ago, the birds settled down to stability about half-way through the Tertiary Epoch, about twenty or thirty millions of years back, and since then, though they have doubtless sprouted out innumerable tiny side-twigs of new species and genera, do not seem to have made any real evolutionary progress." Nor, he adds, are they in the least likely to achieve any in the future since they appear to have reached the limit of perfection attainable in the circumstances prevailing upon the earth, by the kind of creature which they are. Mankind has certainly speeded up the previous rate of aeronautical evolution.

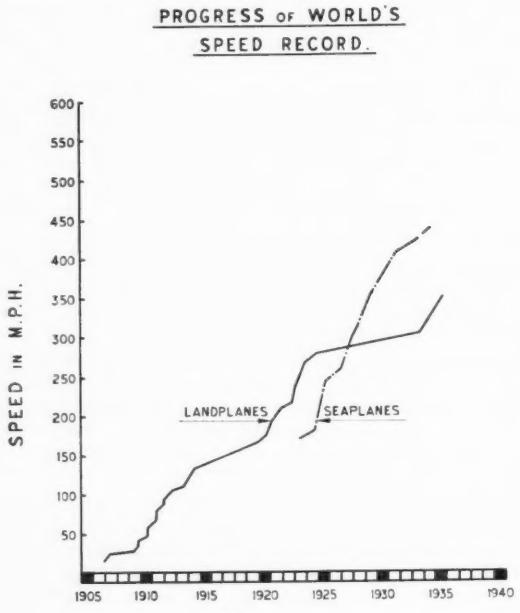


FIG. 1.

HIGH SPEED

I think I cannot do better than approach the problem of the attainment of high speed than by quoting from the Creevey papers. The adventure related, took place just over one hundred years ago.

> "To-day we had a lark of a very high order. Lady Wilton sent over yesterday from Knowsley to say that the locomotive machine was to be upon the railway at such a place at twelve o'clock for the Knowsley party to ride in if they liked, and inviting this house to be of the party. So of course we

* Bird Watching and Bird Behaviour.

were at our post in three carriages and some horsemen at the hour appointed. I had the satisfaction, for I can't call it pleasure, of taking a trip of five miles in it, which we did in just a quarter of an hour. . . . . The machine was occasionally made to put itself out or go it; and then we went at the rate of twenty-three miles an hour. . . . . But the quickest motion is to me frightful: it is really flying, and it is impossible to divest yourself of the notion of instant death to all upon the least accident happening. . . . . Altogether I am extremely glad indeed to have seen this miracle, and to have travelled in it. Had I thought worse of it than I do, I should have had the curiosity to try it; but having done so, I am quite satisfied with my first achievement being my last."

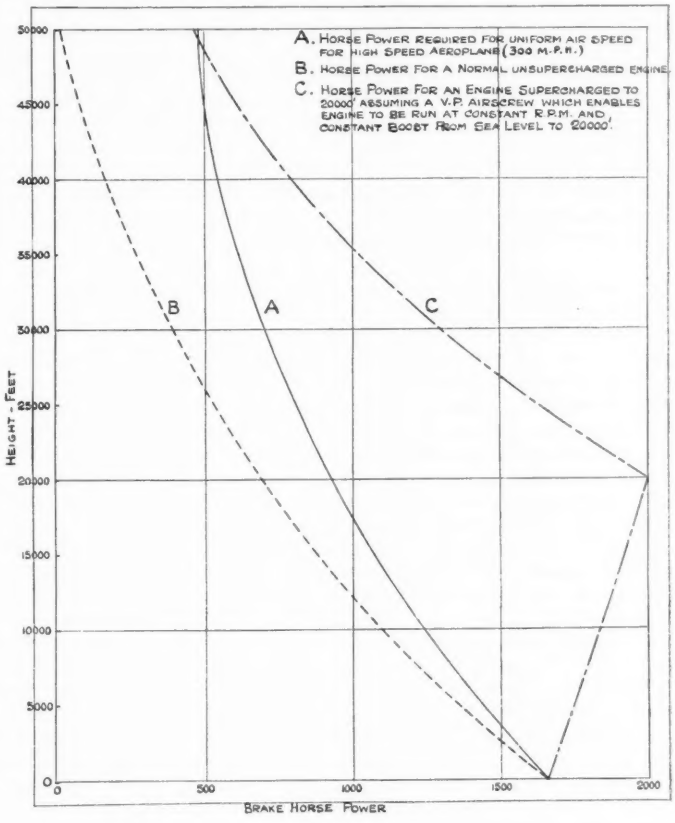


FIG. 2.

Power against altitude for constant speed.

Perhaps it was his last but others were more adventurous. Around the attainment of high speed, immense human interest has always centred. The breaking of such records now rank as international events, and the world probably spent a million pounds over the last Schneider Trophy Race. It is estimated that the "record" has been rising steadily for 25 years at an average rate of 15 m.p.h. annually. Where is this to stop? Must it stop?

The attainment of very high speed depends upon combining great engine power with low aeroplane drag. It is less obvious how it will depend upon the altitude of flight. The latter question, however, is very important, and perhaps we may consider it first. As we increase height we decrease air density, and therefore decrease drag, so that flying at altitude, if speed is desired, seems good sense; but this simple conclusion is complicated by the engine factor and several others. Let me deal first with the engine. The engine power is as much affected by change of air density as is the drag, and how do these conflicting tendencies balance the one against the other? This is, I think, most easily seen by drawing a single curve showing for a representative design the amount of engine power necessary at all heights in order to produce a specific level air speed. With such a curve-sheet (kindly drawn for me by Mr. A. R. Collins), it is simple to add a graph showing the power which would be given at each height by the engine; then when the engine is shown by the curve-sheet to be giving more power than is required for the basic speed chosen, it is clear that a higher speed is attainable. A glance at this illustrative diagram shows that this increase of speed is at its maximum at the rated height of the engine (*i.e.*, the height at which the supercharger just maintains the power at its sea-level value), and that afterwards the surplus power, and therefore the additional speed, will fall off till the two curves cross, which they do at the altitude at which the speed is again at its original value. This diagram shows in a simple way that merely pushing up the height of flight without paying attention to the way in which the engine is affected by that height would be foolish. Merely pushing up the altitude will not give greater speed.

Moreover, increase of altitude brings in other effects which we must not ignore. One is that when flying near the ceiling, the angle of incidence is increased, and with that increase comes a growth in the relative proportion of induced drag to parasitic drag: this formerly quite small fraction now becomes too large to be ignored and its effect is to bring down the speed attained. Further, there has to be considered the effect of change in Reynolds number with height of flight.

The Reynolds number is too well known to need description, but it is less well known that change in that number as an aeroplane climbs to a height has an important and adverse bearing on the drag coefficient. For a given wing, wing loading and angle incidence, the dynamic pressure ($\frac{1}{2}\rho V^2$) is the same at any altitude. But since Reynolds number is proportional to both density and air speed (ignoring for the moment any change in the viscosity of the air which affects but does not change the conclusion), it follows that the Reynolds number must fall as the air speed rises; hence the Reynolds number at a high altitude of flight, despite the higher speed, will be lower than at a less altitude.* Any lowering of the Reynolds number means an increase in the drag coefficient for both laminar and turbulent skin friction. Hence for flight at altitude one must allow a higher drag coefficient than would correspond to sea level conditions. This is a factor adverse to attaining great speed at height.

Apart from these particulars, the question of getting the highest possible speed is one of providing an aeroplane which, while comfortably containing pilot and engine, will have the minimum amount of " wetted " area in proportion to engine power. Obviously, the body must be such as to house the pilot comfortably; this provides a certain cubic capacity for the engine space in front of him, which in turn governs the amount of power that can be derived from the engine. Would one get any more speed by building a more spacious aeroplane? Since a ten per cent. increase in dimensions would put up the engine power possibilities by thirty per cent. and the wetted area by only twenty per cent., it is clear that it could, although with the disadvantage of an increased landing speed. For any size of aeroplane, however, the amount of power available related to the drag coefficient which corresponds to turbulent skin friction, gives a

* Cf. Von Karman on The Problem of Resistance in Compressible Fluids—Rome, 1936.

definite limit to the speed attainable unless some method of getting still more engine power from that given space, or of reducing (if we know how to) some part of the drag to the lower level which corresponds to laminar flow. As Relf pointed out in his 1936 James Forrest lecture, to make the flow remain laminar over the whole surface would be to reduce the drag to one-tenth of the values now normal. This I do not think we shall ever attain, but whether we do or not, we can at least ensure that wing surfaces shall be made exceedingly smooth, particularly near the leading edge and very particularly on the upper surface of the wing; and we can see that when flush riveting cannot be used, the shape, and place, of the rivets is such that they do not project through the laminar layer. Steps can also be taken, now that the technique is known, to reduce greatly the engine cooling drag—even if it may be to convert it most marvellously into a small thrust.

Action on these lines applied to the designs of to-day soon brings one close to the most formidable of all nature's fences; that is the natural limit to the speed with which the air is able to get out of the way of the advancing aeroplane. The speed at which air can move when pushed is the same as the velocity of sound, and once the aeroplane speed approaches this boundary, it becomes more and more difficult to push away the air in front. And there is nothing we can do to increase the velocity of sound.

Perhaps we should study the mechanism more closely. When a body moves it compresses the air just in front of it, and the resulting pressure is communicated to the air further ahead. This communication is, as I have said, carried out at the velocity of sound in the medium. In air of normal sea level pressure and temperature, this velocity is 750 m.p.h. At greater altitudes it is less, not because the pressure is less, but because the temperature is. If the temperature were everywhere the same, the velocity of sound would not change. Actually the square of the velocity is directly proportional to the absolute temperature, so that in the stratosphere instead of being 750 m.p.h. it is only 650 m.p.h.

What precisely happens when the speed reaches this limit? When that happens, the air ahead cannot be " warned " of what is coming. This leads to as many shocks and collisions as if an unlighted motor car tried to get through a crowd of deaf people on a dark night. When an aeroplane moves as fast as, or faster than, the velocity of sound, collisions with the air particles are inevitable and there will be an enormous loss of energy, through conversion into heat in the resulting shock waves. Hence the drag coefficient rises to a high value as the velocity of sound is reached, and although it subsequently recovers somewhat it still remains very much higher than the sub-sonic figure. Moreover, every roughness point on the aeroplane produces its own shock wave and therefore its own particular loss of energy. It is true that the lift coefficient also increases at this time, but the ratio of the lift to drag is substantially reduced and a less efficient aeroplane results. To some extent this might be thought to be overcome by a change of wing section, but since the wing section cannot well be changed during flight, no compromise wing section can be the best both at sub-sonic and super-sonic speeds.

The forms of aerofoil employed for the air speeds customary to-day have been studied unremittingly—even exhaustively. Much less is known of those suited to super-sonic speeds though work on airscrews gives us some lead. But it seems that sharper leading edges will be needed and wings less deep than at present. Even so, the best lift to drag ratios may be nearer five than twenty, and this, if it continues, will have striking consequences. Let us consider what could be the physical requirements of an aeroplane flying at a speed equal to the velocity of sound. An aeroplane weighing a ton will have a drag of one-fifth of a ton on wing drag only, and perhaps as much as one-third of a ton over all. This for a speed equal to the velocity of sound will require one thousand five hundred horse-power per ton—and as this is the net figure the gross may be roughly put at two thousand. But a present-day engine of this size would

require the whole of this weight allowance and there would be none left for the airframe and its contents! If speeds such as these are to be attained it cannot therefore be by the engine as we know it to-day.

In point of fact the limit to speed is reached even more rapidly than these considerations indicate, since the air speed just above the top of the wing is appreciably higher than the air speed of the machine itself. Hence the critical boundary will be reached while the air speed of the aeroplane is still substantially below the velocity of sound. Taking everything into consideration, there is much to be said for assessing the maximum possible speed of level flight with the present type of engine as over 500 but less than 600 m.p.h. It is true, however, that if we could suppress everything but laminar drag, or if there were some entirely new prime mover invented giving vastly greater thrust than an internal combustion engine of the same cubic capacity (even one using the very latest fuels of the highest octane numbers), it might be still possible to force the aeroplane through the air at even higher speeds. But there is not the least present indication of either of these being practically possible. So 600 m.p.h. is likely to remain the limit to the speed of human flight.

The highest speeds to-day are all sea level speeds, but the greatest speeds in the near future are likely to be attained at high altitudes, though as they will be the achievement of military types we shall not hear much about them; a few years later they will again be attained at sea level—since at sea level the velocity of sound barrier is not so soon encountered. At sea level therefore it is that human flight will reach the limit imposed by nature's unclimable fence.

The Power of Manœuvre

In many forms of aircraft, power of manœuvre is vital. Does the increasing speed of flight have any effect on this vital requirement whether because of a limit to the endurance of the human body or of the aeroplane itself? It is also important to know whether we are approaching some physiological limit to either the rate of climb or the vertical speed of dive. We are all more or less familiar with what is known as caisson disease. This trouble arises when a diver working under several atmospheres of pressure, with much nitrogen absorbed into his blood, comes to the surface and the surplus gas bubbles out as the pressure is relieved. During the climb of an aeroplane, the atmospheric pressure is also gradually relieved, but here the rate of change of pressure is so slight, and the total change of pressure so small, that the physiological effect is unimportant. Since, however, the rate of dive is vastly greater than any possible rate of ascent, it is reasonable to ask whether in this more rapid action physiological difficulties may not occur. Here an arithmetical parallel is of service. Even if we take a direct dive through 8,000 feet at as high a speed as 400 m.p.h., the total change of pressure is no more than any swimmer would encounter who dived 10 feet deep into water; moreover, the total time taken by the air dive, some seven or eight seconds, does not represent anything more sudden than would be encountered by such a swimmer. We may therefore conclude that there is little to fear in this case also. As Wing Commander G. S. Marshall, of the R.A.F. Medical Service, put it in his lecture* to the Society: "Power dives are done at the almost unbelievable speed of 30,000ft. per minute without apparent harmful biophysical effect." As regards acceleration in taking off, or deceleration in landing, these are not anything to which the human frame does not easily adapt itself. This applies also to the catapulted take-off. The acceleration to which we are all subjected in a motor car driven in normal London traffic is just as severe!

There are, nevertheless, other accelerations which arise during flight which are of a totally different character. These are the ones due to centrifugal force. An aeroplane steadily banked on a turn at 45 degrees will impose a horizontal

* R.Ae.S., January, 1933.

force on its occupants equal to their own weight and this combines with the normal weight of the body so that the total weight on the passenger's seat is increased by almost half as much again. Banking at 60 degrees would double this load.

There are also large centrifugal forces introduced when an aircraft suddenly pulled out of a dive. In almost any aircraft the controls are so powerful that it is mechanically possible for the pilot so to manipulate the elevator as to break a wing. Of course, for this to happen the acceleration imposed has to be exceedingly great, equivalent, perhaps, to twelve times the gravitational acceleration, commonly known as 12 g. It fortunately happens, however, that the human body shows warning signs of distress long before the aeroplane. When, for instance, an acceleration force of 5 g. is encountered, the body is affected in the same way as it would be were the blood suddenly increased to five times its normal specific gravity. The effect naturally is that the blood seeks a lower level, and by denuding the brain of its normal share, causes the failure of visual faculties known as "blacking out." This produces no permanent effect, but for the time being the pilot sees nothing, and even though he still maintains control of the machine, it is a control unguided by any visual information from either the instrument board or the external world. Even higher accelerations than this have been endured by pilots, though not with any degree of happiness. I have read of an American experience of 11 g. requiring subsequent hospital treatment, and of 15 g. leading to a complete crash, though in the latter case it was difficult to distinguish between the results of human failure and the failure of the aeroplane structure. Nature does then impose a definite limit to the safe rate of pulling out from a dive and that limit is a physiological one and difficult to modify by human ingenuity. One alternative is to await the long process of normal human evolution and another to induce pilots to adopt the prone position when flying—the one change might take as long to bring about as the other.

It will be natural to ask what happens to the human frame when the acceleration comes in the opposite direction, that is towards one's head instead of towards one's feet. This is what happens in the manœuvre known as "the bunt," and there then arises a suffusion of the brain by more than its normal supply of blood, leading to what is known as the "redding out" of vision. This manœuvre is, however, always a dangerous one and on it authority frowns.

We have lastly to consider what I mentioned first, the effect on manœuvre of the steadily rising air speeds of modern aircraft. The relationship is a simple one. The measure of the acceleration which has so marked a physiological effect is proportional to the product of the angular rate of turn by the linear velocity. If, therefore, the linear velocity be doubled, as has indeed happened over a comparatively short range of years in typical aircraft, the rate of manœuvre must be halved if the safe acceleration limit is not to be passed. It follows from this that as machines become more and more speedy, so they must become less and less manœuvrable. The effect of this on the dog fighting of the past is outside the scope of this address, though it is an interesting subject on which to speculate.

Let the speeds of aircraft increase as they may, the speed of nerve impulses in the human pilot will remain unchanged, namely, about 100 metres per second. Moreover, as in other means of signalling, terminal delays need to be taken into account. It appears that when a nerve impulse starts from say the hand to reach the brain, the overall time taken for the response is very much longer than that of the mere passage of the signal along the nerves. This time lag before the brain is able to act on information received was, I feel sure, an important factor in some tests carried out a number of years ago at Farnborough. It was then thought that it would be a good thing if an indication could be given to the pilot when he pulled out from a dive, of the moment when he put on an acceleration higher than was safe. This indication was given by having inside the control lever a tiny accelerometer unit which, when the acceleration passed any set limit, say, 4 g., jerked the pilot's hand. The jerk warned him that it was

advisable to slacken off the rate at which he was pulling out. The instrument worked well, but the idea failed because, although the indication was given to the pilot's hand and thence to his brain, the airplane was too quick for the combination. Careful laboratory tests showed that it was impossible for the pilot to push the control lever forward in less than one-fifth of a second after the indication had been given by this device to his hand. In actual flight the time lag might be longer. In the words of the Report* presented to the Aeronautical Research Committee: "In the case of intentionally violent use of the controls no warning however swiftly given could be of service to the pilot."

Incidentally, anyone who wonders what an acceleration of 5 g. is like can obtain the information without getting into an aeroplane at all. Consider a child swinging in an ordinary garden swing. If the child swings up to such a height that he can just see the horizon over the top bar he will experience as he rushes past the bottom of the swing an acceleration force of 3 g. If the swing be of the fair type with iron rods in place of ropes we can in theory, at any rate, start the swing from the very top (so that the poor child is inverted and has to be strapped in). In this extreme case the acceleration force when the seat swings through its lowest position will be exactly 5 g.; and this it will always be whatever the height of the swing or the weight of the child.

(An experiment with a recording accelerometer was exhibited at this point to show the acceleration reached at the bottom of a swing.)

The effect of applying to the human body a steady lateral acceleration can also be illustrated by an ingenious device at the University of Göttingen, where a cylindrical room is mounted on bearings so that it may be rapidly rotated. People standing in that room see nothing but a dial to tell them that the room is being rapidly turned round, but the effect upon their limbs when they try to use them, and still more on their mental sensations when they suddenly incline their head serves to show how easy it is to deceive the brain as to what is taking place. The relation of this to the spinning aeroplane is of interest.

The Extreme Altitude of Flight

I come now to the problem of high flying. What are the conditions which limit the altitude of flight? We know that the higher one flies the lower the air density and the smaller therefore the quantity of oxygen that passes into the human lungs and into the engine cylinders. The engine itself is really almost human. It breathes in air, it takes in fuel, it changes it chemically, gets rid of waste products, maintains its own warmth and does not like being either too hot or too cold. Like the human body it is liable to suffocation and needs supercharging or the equivalent thereof. There are two effects to consider, the effect of oxygen want in the human body and of a similar lack in the aeroplane engine. It so happens that the effect on the former operates much more rapidly than it does on the latter. Both are accustomed to working under normal atmospheric conditions at sea level where the pressure is about fifteen pounds per square inch, and the proportion of oxygen in the atmosphere about one-fifth of the whole.

We are fortunate in having a careful study of this question in a lecture delivered by Professor G. T. R. Hill before the Royal Society of Arts in 1935. I think his conclusions are entirely correct—certainly on this point—and it is worth summarising them. Since the air pressure at 35,000 feet is just one-fifth of what it is at sea level, it follows that human beings will be as well off with oxygen at that altitude as by breathing ordinary air at sea level. But experience has shown that even without any artificial supply of oxygen, flight at 15,000 feet is possible; the lungs can adapt themselves to that condition of slight oxygen starvation—provided that no particular bodily exertion is called for. Supplying pure oxygen at 42,000 feet would correspond to this same degree of starvation. But when

* R. & M. 1446.

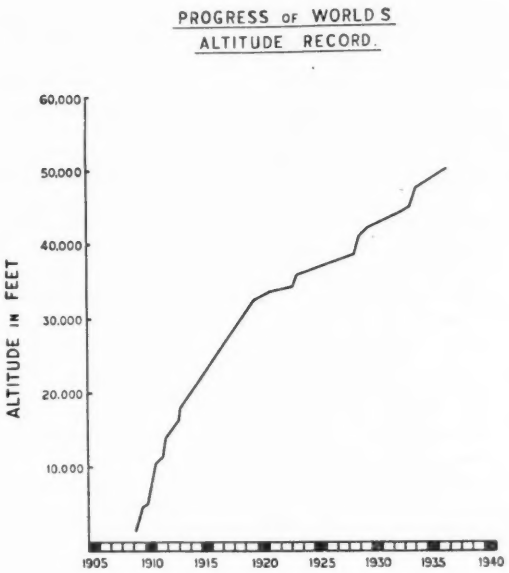


FIG. 3.

45,000 feet is reached oxygen starvation reaches the fainting point—a condition similar to that which arises in the absence of oxygen at some 20,000 feet. The supply of pure oxygen to the pilot, making the oxygen richness approximately five times as large as it would otherwise be, has therefore the effect of postponing the normal fainting point for the average pilot to some 45,000 feet, which corresponds very closely to the altitude records obtained in recent years when the pilot was fed in this way. Thus Uwins reached some 44,000 feet in 1932, and Donati 47,000 in 1934. The opinion expressed by Wing Commander G. S. Marshall* some four years ago was that whilst the safe limit of height for a person breathing pure oxygen was 44,000ft. on a flight straight up and down again, he would not state this to be the limit of possible human endurance. How high birds can fly I do not know, but Mr. Hugh Ruttledge showed in a recent lecture on an Himalaya climb a photograph of a lark sitting on her eggs at a height of 18,000 feet. And I suppose she did not get there on her feet!

The existing altitude record of 50,000 feet, obtained in 1936 by Flight Lieutenant Swain in a Bristol aeroplane, was reached in a different way. In this case the pilot was enclosed in a suit—rather like a diver's suit—which could be kept at a pressure of several pounds per square inch higher than that of the external atmosphere. Oxygen is preferred for such a suit because of the lower pressure required and hence the greater ease of movement. Actually 2½lb. per square inch is found to be a convenient pressure, and such a suit has been tested in a low pressure chamber to a " height " of 80,000ft.

Of course, one may go further than a special suit and provide an enclosed cabin in which a suitable internal pressure is artificially maintained. Although there would be grave objections to this in a military aircraft, there would be none in civil machines other than perhaps a reluctance to face the necessarily cramped space in which the occupants would be confined. Although the temperature is low in the stratosphere, flight at high speeds brings its compensation since any

* R.Ae.S., January, 1933.

entering air would be heated by compression by the number of degrees centigrade that is equal to the square of the speed in hundreds of miles an hour, *e.g.*, nine degrees centigrade at 300 m.p.h.

By these expedients it is possible, theoretically at any rate, to postpone indefinitely the failure of the human mechanism, and the limit to the altitude performance becomes solely that of the engine. Does nature here impose a definite limit? At 50,000 feet the air density is but a ninth of that at ground level, and since for practical reasons there is no question of supplying the engine with oxygen, the task of supercharging the cylinders adequately is a severe problem, beyond the capacity in fact of any single supercharger. Efforts to increase the altitude still higher than the present limit must impose more and more severe duties on the supercharging mechanism, which, therefore, must needs increase in bulk and weight. In the limit this very increase in weight makes the attainment of higher altitudes more difficult. So far as present-day possibilities in design are concerned, I may cite the estimate given by Mr. Barnwell in his lecture at Bristol in February last that if one went " all out " for an altitude record a height of 61,000 feet should be attainable.

There must at any future time be a design limit to what is possible in the light of the materials then available, but it would be rash to forecast finality since the one thing which does seem limitless is the fertility of the brain of a designer once new materials become available. At present we have no means of predicting what new materials may arrive in the future. We are but beginning to grope our way through knowledge of crystal lattice structure towards a coming technique of alloy design.

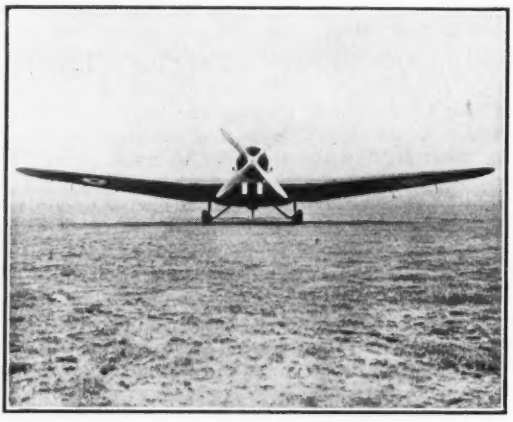


FIG. 4.
Holder of altitude record (Bristol 138).

THE RANGE OF FLIGHT

It is far from easy to find any limits imposed by the laws of nature on the greatest distance that an aeroplane can fly without refuelling. How, for instance, does range of flight depend on the size of the aircraft, the power of the engine and the height chosen? It is sometimes thought strange that aeroplanes of what I may call the same vintage, using the same fuel and with equally efficient engines, show when flying at their most economical speed precisely the same figure of ton-miles per gallon (the figure is the same as that commonly obtained in the ordinary motor car). This is true whatever the size of the aeroplane may be, and whatever the altitude of flight. I suggest that the simplest way to understand this seemingly

strange result is this. At all air densities there is one particular incidence for a given aeroplane which gives the maximum value of the ratio of lift to drag, and therefore, the lowest value of the drag for that particular aeroplane. Hence, when flying level at this incidence, the lift being equal to the weight, the drag must have a constant value. (I ignore for the moment the effect of any change of weight due to fuel consumption.) Now, with a constant drag force the work done to cover a specific distance through the air must be a fixed and definite amount, independent of the air density, and, therefore, of the altitude of flight. If the engine is equally efficient at all air densities, it follows that the work done by the engine must also be the same for any given distance through the air, whatever the altitude. Hence, the minimum ton-miles per gallon must be independent of the altitude. There is no advantage therefore, under still air conditions, in flying high in order to beat the record for range of flight.

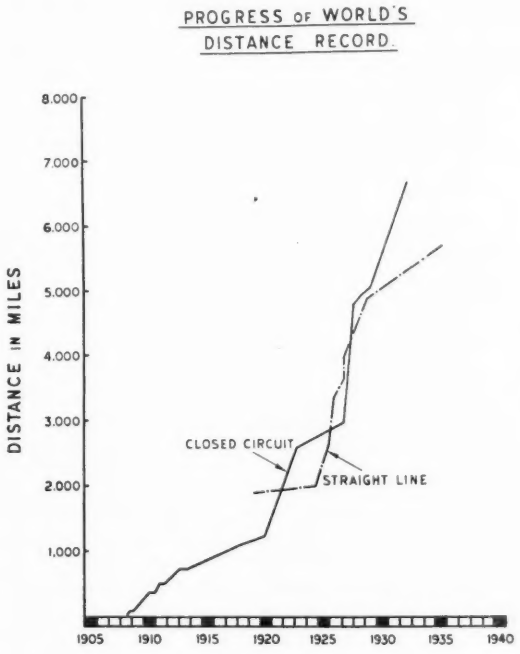


FIG. 5.

In practice, of course, one has to allow for the fact that the total weight will gradually diminish as the fuel is used up. And in normal flying one must also allow for the consideration that flight at a speed which corresponds to the most efficient incidence may not always be operationally convenient, and that is what is found convenient cannot but be related to the speed of the prevailing wind, and since winds vary with altitude, the problem is complex.

Nevertheless, it is a convenient starting point to realise that for aeroplanes having engines of a given efficiency using specific fuels, the maximum possible ton-miles per gallon tends to be independent of altitude. Hence, the natural limit to range of flight depends far less upon the altitude than upon the attainment of high engine economy, of low aeroplane drag, and of so low a structure weight as to allow really large fuel tanks to be carried.

Messrs. Rockfeller and Moore have recently published a forecast that a range of 20,000 km. without refuelling may ultimately be attainable. If they are right, we shall attain a range enough to enable every single spot on the earth to be reached from every other. A conclusion which will please those who have neat minds, but alarm those who love solitude.

SOME REFLECTIONS.

I thing it would be fair to say of all of us that our reflections on this intense aeronautical activity are mixed; even confused. There is the view expressed by Lord Trenchard many years ago (Cambridge in 1925), that if he had his way he would " abolish the air." The same view was wittily expressed recently by a writer in " Truth "—" What a pity, though, that the Creator, when he made flight so difficult to achieve, did not do the job thoroughly and make it absolutely impossible!" But—" Unfortunately, as Adam and Eve learnt to their cost, it is easier to obtain knowledge than to escape from its consequences."

There is, however, another side to this great question. The fears expressed are largely those engendered by a form of warlike attack against which there is thought to be little or no defence. But the struggle between attack and defence has taken place in all ages, and with all forms of weapon; sometimes the pendulum swings in favour of the one and sometimes in favour of the other. With aircraft, the attack has for years been in the ascendant, the pendulum is even now over on that side; but this I am glad to think is a passing phase, and already the pendulum is on the move.

May I quote two striking sentences used by Colonel Lindbergh during a recent visit to Germany—" The responsibility which we incur by creating a powerful destructive force is lightened by the knowledge that this force is being controlled by reason and experience, and that we have separated such a force from ignorance. I find hope in the belief that power which goes hand in hand with knowledge will not be a menace to civilisation."

As I suggested by way of comfort at one of our recent meetings, no country can become materially strong in the new Arm of the Air unless there exists in almost limitless degree noble gallantry in its young men, and fine intelligence in the engineers charged with the development and construction of this Arm. Changes now in sight will, I am certain, call in future years for these great qualities even more intensely. And though the qualities of gallantry and fine intelligence may perhaps not be the supreme human qualities, they are, nevertheless, most noble ones, and it is a happy thought that those countries alone which possess them can become great in the strength of the new Air Arm.

VOTE OF THANKS TO PRESIDENT.

Lord SEMPILL: Professor Hill and he were very proud of the fact that they had been selected to perform so important a duty. They knew for certain that the vote of thanks would be received with very genuine enthusiasm. The President had just delivered a carefully thought out Address. Personally, he felt himself unable to do adequate justice to the occasion, the more so because in this vote of thanks were included, not only expressions of gratitude to the President for his Address, but also for the many contributions he had made to the scientific and technical side of aeronautics, but he knew that all present had a very complete knowledge of the many services that the President had performed during the past twenty years or more, since during that time he had devoted all his energies to aeronautical sciences. It would be quite impossible to do justice in a short speech to this work.

During the last few years he had filled with high distinction a most important scientific post in the Air Ministry, and in so doing he had set an example such as made it possible for only the most highly qualified to follow after him. They were well aware that the man now holding this position would be able to follow in the footsteps of Mr. Wimperis, whom they delighted to honour that evening.

Mr. Wimperis had worked at his official post with a never flagging energy, and had devoted the greater part of the very few leisure hours he had to the welfare of the Society. Scientifically, technically and, more recently, financially, the Society had benefited enormously by all he had done. Those intimately concerned with the Society would be well aware of the difficulties, particularly financial ones, that had to be faced. It had fallen to the lot of Mr. Wimperis to gather certain others around him, and with their aid to place the finance of the Society on a sound basis. He knew that all this work had not yet been fully completed, but it was well on its way to completion, and for that reason, and for others touched upon, he had deserved very well indeed of the Society.

By custom the Presidential Address was not open to discussion and, therefore, remarks had to be confined to a vote of thanks.

He felt he could not do better than sum them up in words used many centuries ago by the father-in-law of the work of a famous Roman pro-Consul, closely associated with Britain, that " Would remain in the minds of men, forever embedded in the very record of things."

Professor G. T. R. HILL: In seconding the vote of thanks, he said that those present had listened to a most extraordinarily fascinating account of this aspect of scientific thought, the ultimate achievement of flight. After Lord Sempill's eloquent tribute to the President there was little need for him to add anything. He would just like to say a word, however, about the very human kindness with which the President had always treated him personally. The struggling young inventor enjoyed most welcome encouragement if he had the good fortune to find someone such as the President to give him a helping hand, as he himself so often had in the past. He also wanted to thank the President for his kindly reference to himself in the address, but he was bound to add that both he and the President's staff who looked favourably at his calculations had to suffer a serious rebuke by someone from America who said that evidently the calculations in the lecture had been carried out by an engineer of mediocre calibre!

The relation of the animal kingdom and natural flight had been referred to again and again, and he noticed in the columns of *The Times* that very morning there was the definite assertion that not only the condition of the air, its humidity and temperature, but also the barometric pressure, had a distinct and powerful effect on development in pigs. It seemed, therefore, that they must look forward to the introduction of supercharged pigstyes for farms at high altitude!

The present occasion was one not only for paying a tribute to the President, but for saying how very fortunate they felt themselves to be in that the affairs of their Society were in such excellent presidential hands, and he called upon those present to join with Lord Sempill and himself in thanking the President for his address.

The vote of thanks was carried with loud applause.

The PRESIDENT thanked the members and visitors most warmly for their kind reception of his address.

TWENTY-FIFTH WILBUR WRIGHT MEMORIAL LECTURE.

The Twenty-Fifth Wilbur Wright Memorial Lecture was given at the Institution of Electrical Engineers, London, on Thursday, May 27th, 1937, by Professor von Kármán, of Pasadena University, California, on "Turbulence," before a distinguished audience.

In the chair, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S.

The PRESIDENT: This was the chief scientific occasion in the year of the Royal Aeronautical Society and the lecture that was to be given was in honour of the Brothers Wright who did such splendid pioneer work in the study of aeronautics. It had been the aim of the Society since this lecture was founded to invite a distinguished lecturer to address the Society, and it had been the custom that in alternate years the lecture should be given by an Englishman, and in the other year by a non-British subject. In this year they were very fortunate indeed in having as their lecturer Professor von Kármán.

On the occasion of these lectures, continued the President, it had been the custom of the Society to send a telegram to Mr. Orville Wright, and he had had one sent in the following terms:—

> "On the occasion of the delivery of the 25th Wilbur Wright Lecture on May 27th by your distinguished fellow citizen, Professor von Kármán, the Council and all the members of the Royal Aeronautical Society send you their cordial greetings and wish to assure you of the exceedingly high esteem in which they hold the splendid work of your brother and yourself. No invention has had a more profound effect on the history of mankind.
>
> WIMPERIS, *President.*"

The following reply was received by the President:—

> "Dear Mr. Wimperis,—It gave me much pleasure to receive your telegram of cordial greetings and good wishes. Please convey to the Council and Members of the Royal Aeronautical Society my most sincere thanks.—Sincerely yours,
>
> ORVILLE WRIGHT."

Continuing, he said that Professor von Kármán was well known to all the members of the Royal Aeronautical Society by his work. A very brief account of his record showed that he was Professor of Aeronautics and Director of the Aeronautical Institute in the University of Aachen for 17 years immediately preceding 1930. Since then he had been Professor of Aeronautics in the Daniel Guggenheim Aeronautical Laboratory in the California Institute of Technology, in which distinguished position he had had the opportunity of carrying out aerodynamical research work of the most fundamental character, and of the results of some of that work he had no doubt that Professor von Kármán would speak in the present lecture.

TURBULENCE.

By Dr. THEODOR VON KARMAN, F.I.Ae.S.

When I received the invitation to deliver this Memorial Lecture, and "Turbulence" was chosen as the subject, I remembered that my good friend, G. I. Taylor, gave a very stimulating talk on the same subject ten years ago. It was his G. I. Symons Memorial Lecture before the Royal Meteorological Society. He succeeded in fulfilling his job without using one mathematical symbol, the President of the Society, Sir Gilbert Walker, insisting very definitely that "turbulence without tears" was what he wanted. I do not think that I can duplicate Taylor's achievement completely; however, I shall try to reduce the mathematics to a minimum.

1. TURBULENCE DEFINED.

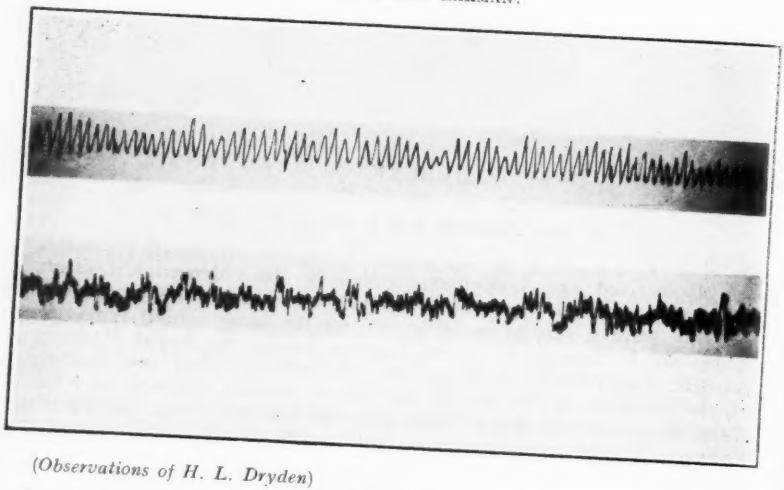
We may start the discussion with Taylor's definition of turbulence:—"Turbulence is an irregular motion which in general makes its appearance in fluids, gaseous or liquid, when they flow past solid surfaces or even when neighbouring streams of the same fluid flow past or over one another."

The emphasis in this definition lies on the word "irregular." Taylor says further:—"The actual motion is usually so irregular that very little is known of its details."

Then, the question arises, why are we interested in such an irregular phenomenon and what gives us the hope that its study will ever lead to practical results?

Well, turbulence is far from being the only irregular motion or irregular phenomenon which physics tries to analyse. As a matter of fact, regular motion is a rather exceptional case in nature. Even the laminar or streamline motion appears as regular motion only to the human observer who looks at the molecular world from so far away and with such rough instruments that he is able only to see the average motion of matter and to measure the average values of physical quantities. Then he finds, in spite of the irregular character of the actual motion, simple relations between the average physical quantities and simple laws for the average motion. Instead of "in spite of the irregular character," we rather have to say, "because." As a matter of fact, the highest degree of irregularity, the random character of the molecular motion enables us to apply statistical methods and to obtain simple relations which are not strictly exact, but have a high degree of approximation, satisfactory in all but some exceptional cases.

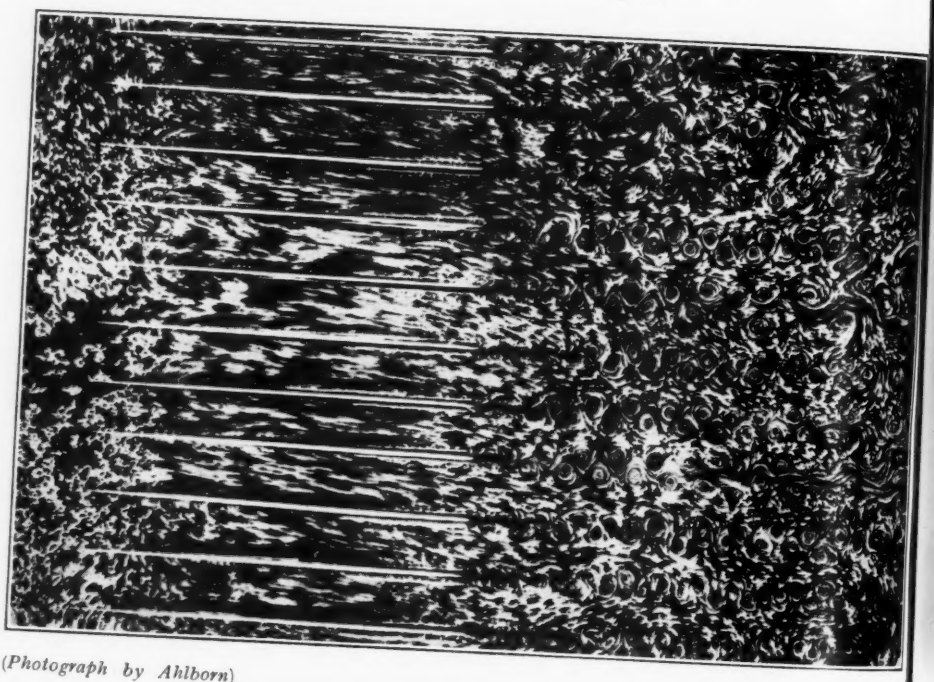
We know, since the researches of O. Reynolds, that "turbulence" is a statistical phenomenon. It was said that turbulence in a fluid is produced by flow past solid surfaces. It is known that if a fluid passes round a body, and the body is not carefully streamlined, often regular vortices appear in its wake. Recording the velocity as a function of time at a point of the wake, we obtain periodic fluctuations, as shown by the upper oscillograph record in Fig. 1. The honeycomb shown in Fig. 2 produces a multitude of vortices. If we go sufficiently far down stream, the regular character of the vortices disappears and our velocity record obtains a definitely irregular character (upper curve in Fig. 1). In the fluctuating velocity field produced in this way no trace of the original vortex arrangement or of the individual wind-shadows of the honeycomb elements is left. We have a uniformly distributed eddying motion; the velocity fluctuations



(*Observations of H. L. Dryden*)

FIG. 1.

Oscillograph records of velocity fluctuations—
Upper record: In a vortex trail.
Lower record: In turbulent flow.



(*Photograph by Ahlborn*)

FIG. 2.

Flow behind a honeycomb.

are statistically the same at every point of the field and even the components in different directions have the same average magnitude. To the observer moving with the main stream every direction appears equivalent. We call this type of turbulent motion " isotropic turbulence." It will be seen later that this case represents the simplest case of a turbulent velocity field.

Wherever we have the opportunity to observe fluid motion in nature, streamline motion, *i.e.*, the motion without irregular velocity fluctuations, is a rather exceptional case; the flow of water in rivers, the motion of air in the atmosphere are turbulent. The fluid motion with which the engineer is concerned is also turbulent in most cases. Examples of laminar motion are the flow of lubricating oil, the flow of water or steam through small orifices and through pipes of small cross-section, the flow of very viscous liquids, like molten glass or metal.

The next question is, what is the practical effect of the presence of irregular motion; why are we interested in the irregular motion which is superimposed on the main motion?

The answer is that the presence of irregular motion radically changes the order of magnitude of the frictional resistance, the heat transfer and the diffusion of fluids. Hence, the turbulence problem reaches practically into all fields of engineering in which fluid motion plays an important *rôle*, whether the fluid is the medium in which the motion of a body takes place, or is being transported for some purpose, or is an agent in a process involving heat transfer, diffusion, mixing, dissolving, evaporation, combustion, etc.

2. The Mechanism of Diffusion.

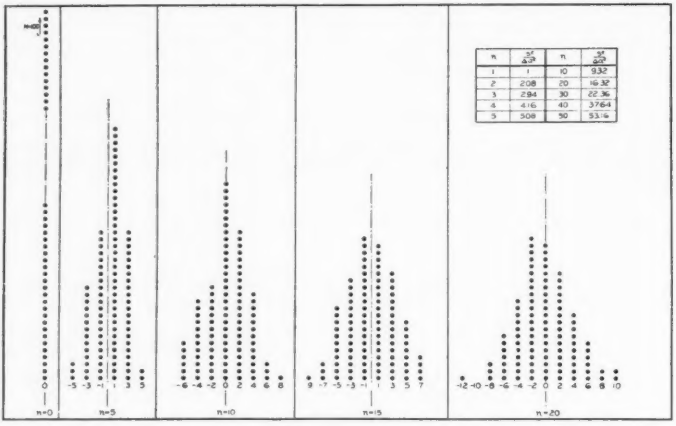
The influence of irregular motion on friction can be visualised by a rather elementary analogy. Imagine soldiers marching along a street in a formation consisting of regular columns. Evidently, if one column is ordered to speed up its pace, no interference from the other columns occurs. Then imagine the same number of persons engaged—in addition to the general forward motion—in an irregular motion across the columns. Undoubtedly, in this case an order to one column to advance relative to the rest of the crowd would encounter considerable resistance. We say there is internal friction between the columns. Applying this picture to the molecules of a gas, it is obvious that the fundamental process which determines the magnitude of the friction is the mixing of the molecules between layers of gas gliding over each other, *i.e.*, the rate at which they penetrate mutually in the neighbouring layers perpendicular to the direction of the main motion. Hence, we consider first the process of penetration somewhat more systematically. The tendency to penetration is due to the fact that the molecules are in permanent unrest; the penetration is resisted by the collisions between the molecules. Let us try to follow the fate of a number of molecules located at a certain instant in one column. For simplicity's sake, we assume that the molecules move only in the direction perpendicular to this column. The effect of the collisions with other molecules will be replaced by the following rule:—We let the particles move by equal steps in certain equal time intervals, the direction in which the particle moves, whether to the right or to the left, being decided by pure chance. If the collisions occur at random, such a probability rule replaces fairly well the effect of the collisions.

The diagram in Fig. 3 represents a distribution of 100 particles after a number of consecutive steps, and is the result of an experiment in which it was determined by the toss of a coin whether the particles move to the right or to the left.

As a measure of the diffusion of the particles from their initial location let us calculate the mean square of the distance reached in the time $n\Delta t$, where Δt is the time interval between subsequent steps and n is the number of the steps. Denoting the total number of the particles by N, the number of those which

have advanced p steps in one direction by N_p, and the length of a step by Δa, the mean square of the distance reached will be equal to

$$\overline{S^2} = \{ (\Delta a)^2 / N \} \sum_{p=-n}^{n} N_p p^2 \quad . \quad . \quad . \quad . \quad . \quad (1)$$



n	$\frac{\overline{S^2}}{(\Delta a)^2}$	n	$\frac{\overline{S^2}}{(\Delta a)^2}$
1	1	10	9.32
2	2.08	20	16.32
3	2.94	30	22.36
4	4.16	40	37.64
5	5.08	50	53.16

FIG. 3.

Distribution of 100 particles for the case of random movement.

The ratio N_p/N is called the probability P_p that a certain particle should make an advance of p steps out of n steps. The theoretical values of P_p, *i.e.*, the limiting values for very large N, are shown in the following table:—

TABLE I.

	R													
n	−6	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	$\Sigma P_p p^2$
1	—	—	—	—	—	$\frac{1}{2}$	—	$\frac{1}{2}$	—	—	—	—	—	1
2	—	—	—	—	$\frac{1}{4}$	—	$\frac{1}{2}$	—	$\frac{1}{4}$	—	—	—	—	2
3	—	—	—	1/8	—	3/8	—	3/8	—	1/8	—	—	—	3
4	—	—	1/16	—	4/16	—	6/16	—	4/16	—	1/16	—	—	4
5	—	1/32	—	5/32	—	10/32	—	10/32	—	5/32	—	1/32	—	5
6	1/64	—	6/64	—	15/64	—	20/64	—	15/64	—	6/64	—	1/64	6

The included table in Fig. 3 shows the values of $\overline{S^2}/(\Delta a)^2$ obtained by the experiment mentioned above. It is seen that for the first five steps the experimental values of $\overline{S^2}/(\Delta a)^2$ are approximately equal to 1, 2, 3, 4, 5, as indicated in the last column of Table I. The theory of probability proves indeed, that if the total number of the particles N and also the ratio N/n is large, $\overline{S^2}/(\Delta a)^2$ is very closely equal to n, *i.e.*, to the number of steps. Or $\overline{S^2} = \{ (\Delta a)^2 / \Delta t \} t$, *i.e.*, the increase of the mean square of the distance reached per unit time is a constant quantity and is equal to

$$\overline{S^2}/t = (\Delta a / \Delta t) \Delta a \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In the case of irregular gas molecules the formula can be interpreted in the following way: The square of the distance reached in any particular direction in unit time is proportional to the mean velocity of the molecules, in our case $\Delta a/\Delta t$, and to the length of the path between collisions, *i.e.*, to Δa. Or we may say that the mean square of the distance reached per unit time is proportional to the square of the mean free path multiplied by the number of collisions per unit time.

The quantity $\overline{S^2}/t \cong$ free mean path × mean velocity is obviously a measure for the process of mixing, and it can be shown that laminar friction, molecular heat and molecular diffusion are proportional to this quantity.

As a first illustration, let us consider two different kinds of particles, initially lined up in parallel columns, the line B—C (Fig. 4) separating the columns which contain the two different kinds. Let us then assume that the particles of each column spread out over the field according to the rules used in the experiment reported above, and calculate the number of those particles which immigrate into foreign territory during a certain time t. (It is understood that only those count that at the end of the period considered are located in foreign territory.)

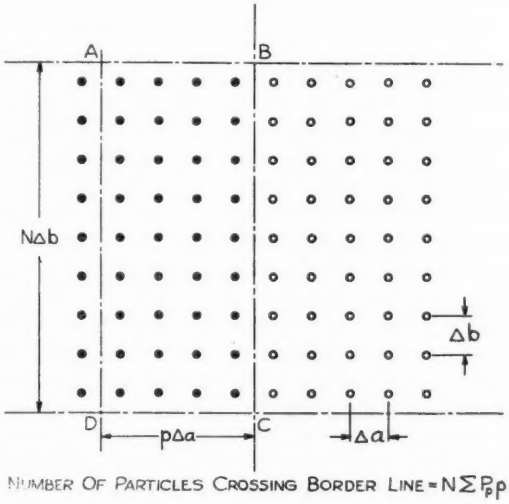


FIG. 4.

Elementary calculations of diffusion starting from discontinuity.

The particles which after the time $t = n\Delta t$ are in foreign territory can be classified in the following way: There are some which have advanced one step, some which have advanced two steps, and so on, up to those which have advanced n steps. Those which reached foreign territory after advancing p steps are initially located in a strip of width $p\Delta a$. If N is the number of those located in one column, the total number of those included in ABCD is equal to pN, the number of those which have advanced p steps is pP_pN. Hence, the total number of particles which have immigrated into the foreign territory in the time $n\Delta t$ is equal to $N\sum_{p=1}^{n} pP_p$. Calculating this quantity we find that for large values of N it is proportional to $\sqrt{n}$, *i.e.*, to the square root of the time elapsed. It follows that the rate of immigration diminishes inversely with the square root of the time. This is easily understood, because, as time goes on, the parts near the border line are inhabited by a more and more mixed population and thus the random migration of the particles produces only slow changes in the statistical distribution. Or in scientific terms: Calling the percentage of one sort of particles the concentration, the gradient of the concentration decreases with the time and, therefore, the diffusion is slowed down.

The Figs. 5*a*, *b*, *c*, *d* give an illustration of this mixing process. Fig. 5*a* shows the original distribution of the white and black particles. The following

process is so schematised, that all particles in one row are supposed to move simultaneously, however in a random way, the probability being determined by Table I. The rows have been moved two units for each step. Fig. 5*b* shows the configuration after three steps, Fig. 5*c* after six steps. Fig. 5*d* shows Fig. 5*c* rearranged to show the resulting distribution.

In order to find the differential law for the process of diffusion let us consider another case, that of an initial constant gradient of the concentration, as shown in the diagram Fig. 6. In this case, it is sufficient to consider the migration of the particles located inside the triangular spaces of which one is indicated in the diagram, because the rest of the particles balance each other as far as their migration is concerned.

The particles which cross the border in the time $t=n\Delta t$ will be classified again according to the number p of the steps they advance during the time $n\Delta t$.

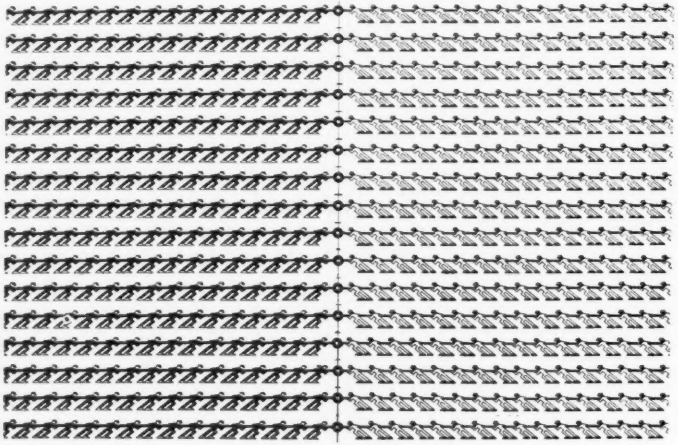


FIG. 5*a*.

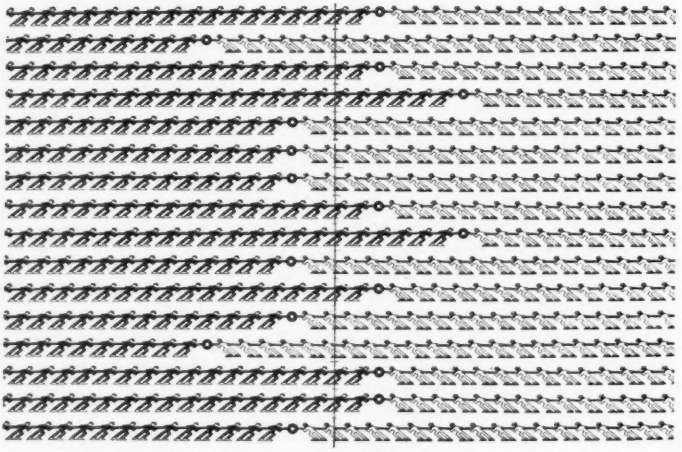


FIG. 5*b*.

From the particles whose advance in this time is equal to $p \cdot \Delta a$, only those can cross the border line, which at $t=0$ are nearer than $p\Delta a$, *i.e.*, those located in the triangle ABC. The number of such particles is proportional to the area of ABC. If the number N of particles of one kind increases by dN/da from column to column, the area ABC is equal to $p^2\Delta a\Delta b\,(dN/da)$ (where Δb is the mean distance between the particles located in one column) and the number of particles in the area is $p^2 dN/da$. Consequently, the total number of particles crossing the border line in the time $n\Delta t$ is equal to $(dN/da)\sum_1^n P_p p^2$. We have seen that $\overline{S^2}/(\Delta a)^2 = \sum_{p=-n}^{n} P_p p^2$. Hence, the number of particles crossing the border line in the time t is equal to $\frac{1}{2}\left[\overline{S^2}/(\Delta a)^2\right](dN/da)$ and per unit time to $\frac{1}{2}(\overline{S^2}/t)\left[1/(\Delta a)^2\right](dN/da)$.

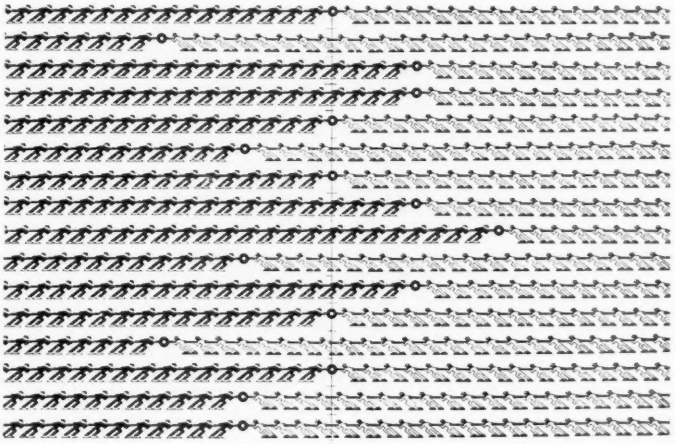


FIG. 5*c*.

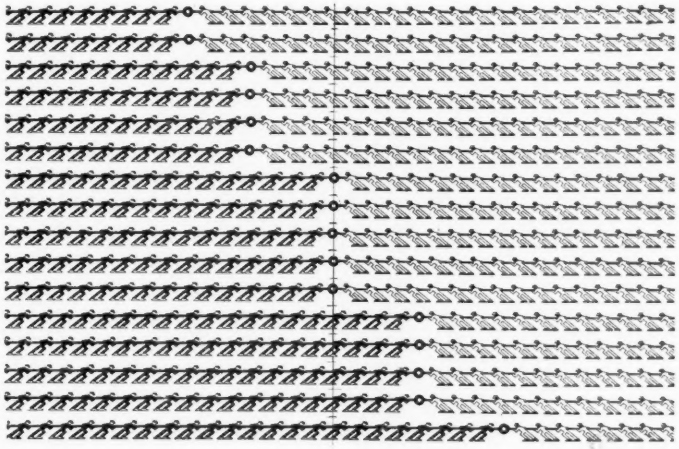


FIG. 5*d*.

Transferring the result to space problems, we find that, N being the density per unit volume of any physical quantity carried by the particles, the flux of this quantity per unit area is equal to $\frac{1}{2}(\overline{S^2}/t)(dN/dx)$, and we call the parameter $\frac{1}{2}(\overline{S^2}/t)$ the diffusion coefficient or the exchange coefficient.

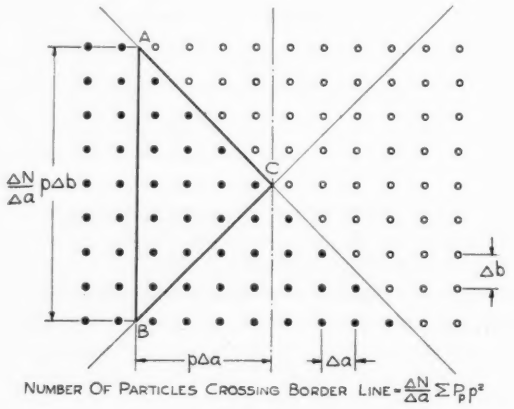


FIG. 6.

Elementary calculation of diffusion in the case of a finite gradient.

The laws of collision between molecules in a real gas like air being more complicated than the rules of play in our game, the different exchange coefficients, such as the coefficient for momentum transfer (friction), for heat transfer, and for the diffusion of suspended particles, are not numerically equal to $\overline{S^2}/2t$; they are, however, proportional to it.

In the case of molecular or laminar friction, the exchange coefficient of the momentum is the coefficient of kinematic viscosity. We may then announce the results of our two examples in the following way. Wherever an exchange process starts from a finite discontinuity such as in the first example, the range of penetration is proportional to $\sqrt{t}$; in a case such as that discussed in the second example, the rate of transfer in unit time is equal to $S^2/2t$ multiplied by the gradient of the density of the quantity transferred.

If heat transfer and diffusion of suspended particles is effected by the molecular mechanism only, similar laws are valid for these processes. In the case of turbulent motion the units carrying out the transfer of momentum or heat or foreign particles like smoke, dust, salinity, etc., are not so well defined as in the case of the molecular mechanism. However, we are able to calculate certain exchange coefficients from observations of turbulent friction or turbulent heat transfer or turbulent diffusion, and we assume these exchange coefficients are a measure of the mean square of the distance reached by the fluid masses, say eddies, which serve as carriers of the quantities or properties involved in the turbulent exchange.

Considering, for instance, that the frictional stress τ is equal to the momentum transferred by unit area in unit time, we write $\tau = \epsilon (d/dy)(\rho u)$, where u is the mean velocity y the co-ordinate perpendicular to u, ρ the density of the fluid. We call ϵ the coefficient of turbulent exchange and we identify it with the quantity $\overline{S^2}/2t$, where S is the distance reached or the range of penetration of the eddies. However, it will be seen later that due to the large dimension of the units involved in turbulent exchange, the laws of the latter are more complicated than the laws of molecular exchange and in general $\overline{S^2}/2t$ is not only variable from case to

case but also not constant in the same exchange process. Nevertheless, the conception of a turbulent exchange coefficient helps us to a general understanding of the phenomena.

3. Examples of Turbulent Exchange.

The first result in this field is the fact that, except in the close neighbourhood of solid walls, the turbulent exchange coefficients are of much higher order of magnitude than the coefficients of molecular exchange.

A few examples will be sufficient to show the large difference between the order of magnitude of the two kinds of exchange phenomena.

As a first example let us consider a point source in a uniform wind stream. The point source may represent a source of heat or a source of suspended particles like smoke. We suppose that the point source produces a certain constant amount of heat or a certain constant number of particles in unit time. The rate of diffusion at an arbitrary distance downstream can be measured by the cross-section which contains, say, 90 per cent. of the amount produced. Let us assume the wind velocity to be equal to 30 f./s. In the case of laminar diffusion, the radius of the circular cross-section containing 90 per cent. of the heat or of the smoke particles (neglecting gravity) will be equal to about $\frac{1}{2}$in. at a distance of 30ft. and 5in. at 3,000ft. It is obvious that—even in a slightly turbulent wind—heat and smoke will spread out very much faster than indicated by these figures.

Or take the example of the cluster produced by an exploding shell. Considering the shell as a point source, it is possible to determine the mean square of the distance reached by the particles starting from the centre of explosion by measuring the diameter of the visible part of the cluster. Fig. 7 shows the values of $\overline{S^2}$ plotted against time, calculated from a few actual records. The dotted line shows $\overline{S^2}$ corresponding to molecular diffusion on a scale enlarged 10,000 times.

It is evident that the turbulent character of the flow of water in rivers and of air in the wind makes it possible for rivers to carry a considerable amount of silt, and for dust storms to extend over large areas. Assuming a certain value a for the mean diameter of the sand particles and a certain value for the magnitude of the turbulent exchange coefficient, it can be approximately estimated how long a time the soil particles lifted from a "blowing spot" will be carried by the wind. (Figs. 8 and 9 are photographs of dust storms taken by the Soil Conservation Service of the U.S.A.) It is known that the velocity of fall of small spherical particles is fairly well given by Stokes's law

$$w = (2/9)\,\eta\,(a^2 g/\nu) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\eta = (\rho_s - \rho_a)/\rho_a$ and ρ_s, ρ_a are the densities of the solid particle and the air.

On the other hand, the root mean square of the height which the particles reach in an arbitrary time t due to turbulence is given by the turbulent exchange coefficient ϵ according to the formula

$$h = \sqrt{\overline{Z^2}} = 2\epsilon t \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Putting $h = wt$, we obtain the following equation

$$t = 2\epsilon/w^2 = (81\epsilon\nu^2)/(2\eta^2 g^2 a^4) \quad . \quad . \quad . \quad . \quad (5)$$

as an estimate for the time during which the particles remain suspended in the wind. The corresponding range (U = mean wind velocity) is equal to

$$l = Ut \cong (40\epsilon\nu^2 U)/(\eta^2 g^2 a^4) \quad . \quad . \quad . \quad . \quad (6)$$

The coefficient of turbulent exchange varies over a wide range with the strength and structure of the wind. The following calculations are carried through with $\epsilon = 10^4$ and 10^5. The value of ϵ for moderately strong winds is between these limits except in the first few feet near the ground, where ϵ decreases with the distance from the ground.

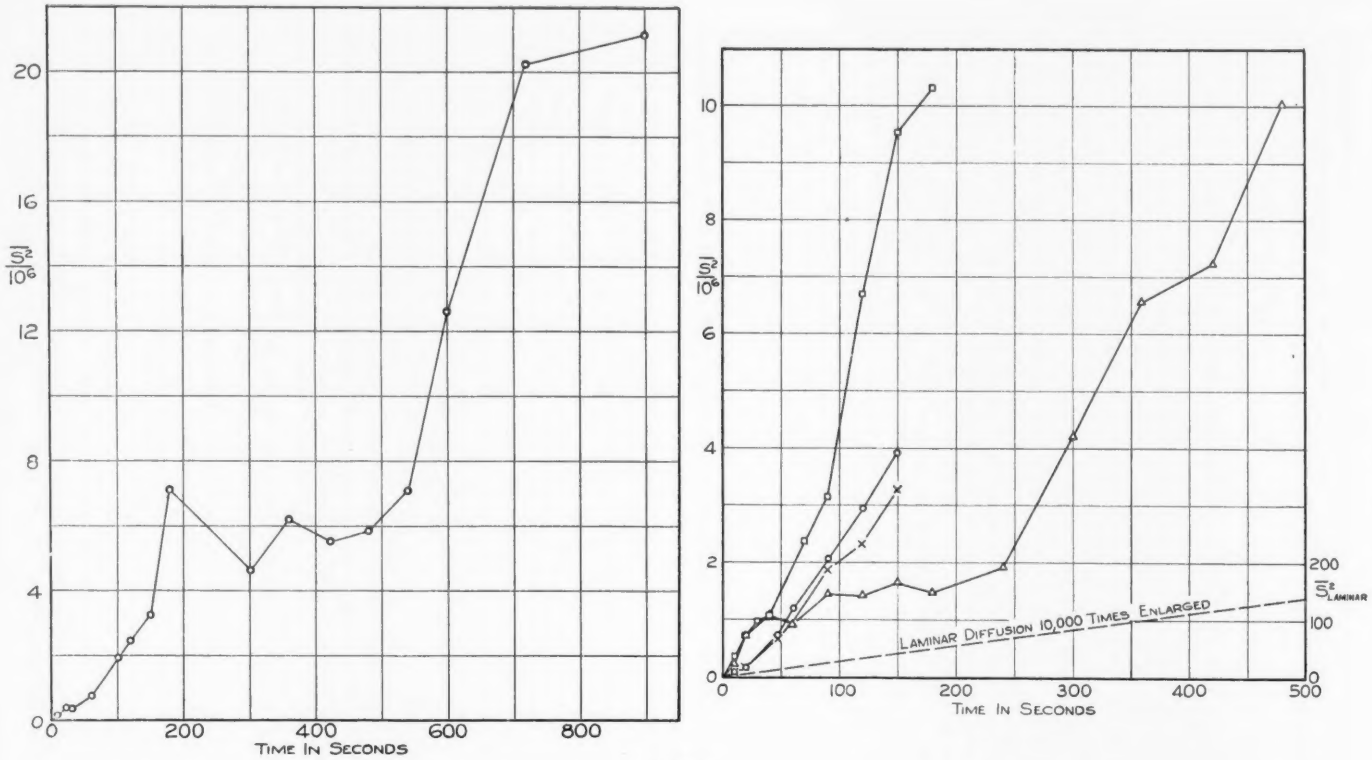


FIG. 7.

The mean square of distance reached by particles in a smoke cluster as function of time.

(Computations based on observations kindly released by the Chemical Defence Experimental Station, Porton.)

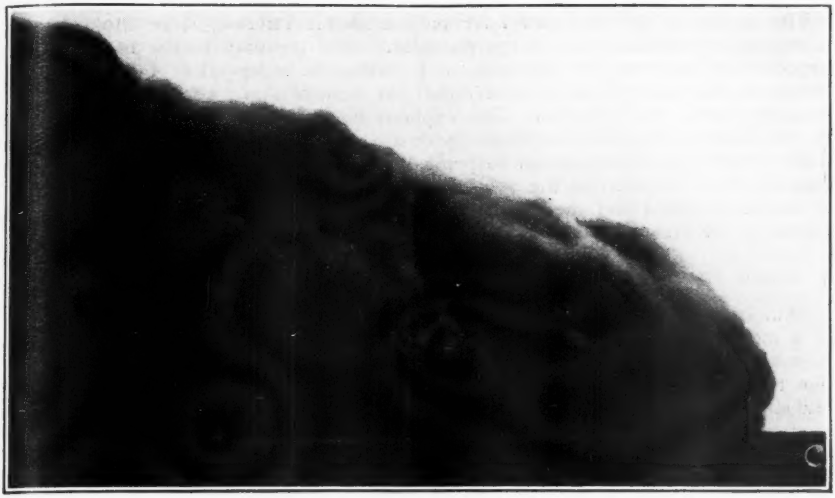


FIG. 8.

The famous Black Cloud of April 14th, 1935, South Eastern Colorado (northern end of so-called Dust Bowl).

TABLE II.

Diameter of particles mm.	Velocity of fall : cm./s.	Time of flight.	Range in miles for 15 m./s. wind.	Maximum height.
0.001	0.00824	9-90 yrs.	$2.5\text{-}25 \times 10^6$ miles.	3.8-38 miles.
0.01	0.824	8-80 hrs.	250-2,500 miles.	200-2,000 ft.
0.1	82.4	0.3-3 sec.	150-1,500 ft.	2-20 ft.
1.0	8,240	0.0003-0.003 sec.	0.2-2 ins.	0.3-3 ins.

FIG. 9.

Dust storm, Central Great Plains.

Photographs kindly released by the Chemical Defence Experimental Station, Porton.)

The figures in the last row have only academic interest, since Stokes's law is no longer valid for such large particles. Also the data in the first row are hypothetical because, for instance, ν is taken as independent of the height. However, the table shows definitely that the time of flight changes very rapidly with the size of the particles. This explains the fact that in most cases the size or the bulk of the particles found in dust storms is between relatively narrow limits. Small particles remain suspended an extremely long time. It is known that after the eruption of the volcano Krakatoa, volcanic ash particles travelled as far as England and the Arctic regions and spent several years in the upper sheets of the atmosphere.

4. When Turbulence Works Against the Aeronautical Engineer.

Skin friction is perhaps the most important factor for the speed performance of a modern aeroplane. Some of our modern planes are aerodynamically clean to such an extent that over 60 per cent. of their total drag is supposed to be due to skin friction. The fact that air resistance consists of the skin friction and of the drag due to the inertia of the medium (" form drag " according to modern terminology) was known already to Newton. He assumed—on the basis of dimensional considerations—that the frictional drag is proportional to the speed of the moving body, and that the drag due to inertia forces is proportional to the square of the speed. Experimental investigations on skin friction started in the eighteenth century. Beaufoy is credited with the first measurements of skin friction of flat surfaces; the systematic experimental work of W. Froude on the subject is very well known. Lord Rayleigh pointed out that the Reynolds number (formed with the speed, the length of the plate and the kinematic viscosity of the medium) must be a characteristic parameter in the problem. The theoretical understanding of the mechanism of skin friction is of relatively recent date. Our modern concept of skin friction agrees with the views of Newton as far as the fundamental law of viscosity is concerned; for the same geometrical flow pattern, the viscous forces are proportional indeed to the velocity. However, the flow pattern around a body is independent of the speed only in the case that the inertia forces are negligible in comparison with the viscous forces, *i.e.*, in the case of very small Reynolds numbers. Then the linear law of Stokes gives the frictional drag correctly. However, if the inertia forces are not negligible the picture is quite different. Consider, for instance, a flat plate parallel to the stream which, without the presence of the plate, is assumed to be parallel and uniform. We know that the action of the viscous forces is significant in a small region near the plate in the so-called boundary layer. According to the fundamental laws of mechanics, the loss of momentum in the boundary layer is equal to the frictional drag. The relative velocity between stream and plate being denoted by U, and the thickness of the boundary layer by δ, the frictional drag acting on the portion of a plate of unit width between the leading edge ($x=0$) and an arbitrary section is equal to

$$F=\alpha\rho\delta U^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where ρ is the density of the fluid and α is a numerical form factor depending on the velocity distribution across the boundary layer. Let us assume laminar flow in the boundary layer, then the friction per unit length—being proportional to the velocity gradient perpendicular to the flow—is equal to $\beta\mu U/\delta$, where β is another form factor and μ is the viscosity coefficient. Consequently,

$$F=\beta\mu U\int_0 dx/\delta.$$

Comparing the two expressions, it follows that $\alpha U^2(d\delta/dx)=\beta\nu(U/\delta)$, or

$$\delta^2=2(\beta/\alpha)\nu(x/U) \quad . \quad . \quad . \quad . \quad (8)$$

Hence, near the plate, with increasing speed the flow pattern contracts in the direction normal to the flow. The frictional drag is proportional to the 3/2 power of the speed and to $\sqrt{(\rho\mu)}$ indicating that the skin friction does not depend exclusively either on the viscous or on the inertia forces, but on a combination of both.

Taking into account that x/U is equal to the time t during which the stream was in contact with the plate between the leading edge and the section considered, we might write equation (8) in the form $\delta^2/t = \text{const. } \nu$. We readily recognise the analogy with the basic law for molecular diffusion discussed in the first paragraph, so that the thickness of the laminar boundary layer can be considered as the range of penetration of the influence of laminar friction into the undisturbed stream.

The reader familiar with the well-known theory of the boundary layer will readily recognise in this outline the basic results of this theory. Having determined the form factors α and β, the theory gives that the coefficient of laminar skin friction referred to the dynamic head $\frac{1}{2}\rho U^2$ is equal to

$$C_f = 1.33/\sqrt{R_x} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where $R_x = Ux/\nu$. The Reynolds number of the wing section of a modern airliner is about 25.10^6. Hence the skin friction coefficient of such a surface would be equal to $C_f = 0.00053$, if no turbulence entered into the picture. The actual value for turbulent friction between fluid and a smooth plate is equal to $C_f = 0.0025$ for the same Reynolds number.

The theory on which our present knowledge of turbulent friction is based is not so complete as that of laminar friction.

We call the transfer of momentum by the irregular turbulent motion through a plane parallel to the mean flow the turbulent frictional stress with respect to this plane; its mathematical expression is $-\rho\overline{uv}$, where $\overline{uv}$ is the mean value of the product of the velocity components in the direction of flow parallel to the plane considered and in the direction normal to the same plane. Hence the total frictional stress is equal to

$$\tau = \mu\,(d\bar{u}/dy) - \rho\overline{uv} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Introducing the turbulent exchange coefficient ϵ, we have

$$\tau = (\nu + \epsilon)\,(d/dy)\,(\rho\bar{u}) \quad . \quad . \quad . \quad . \quad (11)$$

A complete theory of turbulent friction should give information both on the distribution of the velocity fluctuations, and on the distribution of the mean velocity, or, what actually is the same problem, on the magnitude and distribution of the turbulent exchange coefficient ϵ. None of the theories developed so far is able to accomplish this without arbitrary and sometimes inconsistent assumptions. However, the following facts seem to be ascertained by a combination of experimental observation and theoretical—mostly dimensional—considerations. We shall first deal with perfectly smooth plane surfaces.

(*a*) There is a narrow range near the wall in which the laminar friction is overwhelmingly large in comparison with the turbulent frictional stress, *i.e.*, $\mu\,(d\bar{u}/dy) >> -\rho\overline{uv}$.

We call this layer the laminar sublayer. Its thickness δ_0 is given by a relation $(\tau/\rho)^{\frac{1}{2}}\delta_1/\nu = \text{const.}$, where τ is the friction per unit area acting on the wall. Denoting the velocity at $y = \delta_1$ by $U^\times$, we write approximately $\tau/\rho = \nu\,(U^\times/\delta_1)$; hence the Reynolds number of the sublayer $R_1 = U^\times\delta_1/\nu$ is also constant along the plate, *i.e.*, the Reynolds number of the laminar sublayer is a characteristic constant. Its value is of the order $R_1 = 200\text{-}300$.

(*b*) Outside the laminar sublayer is a transition region with a certain thickness, beyond which the turbulent exchange factor ϵ is proportional to the distance from the wall. Correspondingly, the gradient of the mean velocity $d\bar{u}/dy$ is inversely proportional to the distance from the wall. We find experimentally

$$d\bar{u}/dy = (1/k)\,(\tau/\rho)^{\frac{1}{2}}/y \quad . \quad . \quad . \quad . \quad (12)$$

where k is a universal constant, its value being about 0.4. The distribution of the mean velocity follows from (12) by integration:—

$$\bar{u} = (\tau/\rho)^{\frac{1}{2}} \left[A + (1/k) \log \{ (\tau/\rho)^{\frac{1}{2}} y/\nu \} \right] \quad . \quad . \quad . \quad (13)$$

Comparing (12) with (11) we find that the physical meaning of equation (12) is evidently that the turbulent exchange coefficient increases with the distance from the wall. It is indeed $\epsilon = ky\,(\tau/\rho)^{\frac{1}{2}}$.

Equation (12) holds in a range where the variation of τ is small. However, with y increasing τ diminishes and is practically zero at the outer limit of the boundary layer. No satisfactory theory exists at present which enables us to calculate the distribution of $\bar{u}$ in the outer portion of the boundary layer.*

(c) Fortunately the relations (12) and (13) are sufficient to calculate the skin friction coefficient and also the approximate thickness of the boundary layer as functions of Reynolds number. Since the theory of turbulent skin friction based on the relations (12) and (13) has been treated in a number of monographs in the last few years, it appears sufficient to summarise the results. The coefficient of the total skin friction is given by the equation

$$0.242/\sqrt{C_f} = \log_{10}(RC_f) \quad . \quad . \quad . \quad . \quad (14)$$

where $R = Ul/\nu$ (l = length of the plate). The coefficient of the local skin friction (per unit length at the distance x behind the leading edge) is found from (14) by differentiation:—

$$c_f = C_f/(1 + 0.36\sqrt{C_f}) \quad . \quad . \quad . \quad . \quad (15)$$

where C_f is the value according to (14) with $R = Ux/\nu$, and the thickness of the boundary layer δ is calculated most easily using the values of c_f

$$\delta = 0.38\, x\sqrt{c_f}$$

The value of c_f decreases only slowly with x; hence the thickness of the turbulent layer increases almost in proportion to x, while the thickness of the laminar layer increases in proportion to $\sqrt{x}$.

Equation (14) was given first by the author (Fig. 9); the numerical constant was determined by E. Schoenherr. Schlichting found that the empirical formula

$$C_f = 0.455/(\log_{10} R)^{2.58} \quad . \quad . \quad . \quad . \quad (16)$$

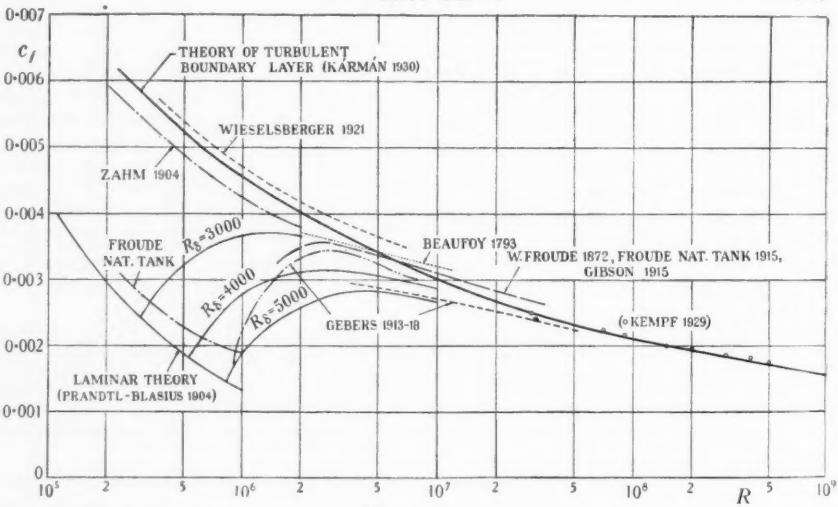


FIG. 10.

Skin friction of smooth flat plates compared with the theory.

* For an attempt in this direction see Howarth, Proc. Roy. Soc. A, **154** (1936), p. 364.

approximates equation (14) very well over the whole range of Reynolds numbers which is of practical importance. This formula has the advantage of expressing C_f directly as function of the Reynolds number.

The results summarised under (*a*)-(*c*) are useful for performance calculations and especially for extrapolation of wind tunnel tests. If, for instance, the contribution of skin friction to the total drag of a wing is known, the decrease of the drag due to scale effect (influence of Reynolds number) can be estimated by using the theoretical skin friction formula. However, there are unknown factors which often interfere with the known factors and in order to give a fair picture of our knowledge of skin friction, these factors of ignorance must also be mentioned.

The total skin friction of smooth surfaces consists of the skin friction of the forward portion where the boundary layer is laminar and of that of the rear portion where the boundary layer is turbulent. If $R = Ul/\nu$ (where l is the total length of the surface in the wind direction) is very large, the contribution of the laminar portion can be neglected. For smaller values of Reynolds number (about $10^5 \leqq R \leqq 10^6$) the two contributions are of the same order, and plotting the coefficient of the skin friction as a function of the Reynolds number, a so-called " transition curve " is obtained connecting the curve corresponding to equation (9) with that representing equation (14). However, the transition from the laminar to the turbulent régime does not occur in all cases at the same Reynolds number, but depends largely on the shape of the leading edge, *i.e.*, of the front portion of the plate or streamlined section, and especially on the turbulence level in the outside stream. Consequently, not one transition curve, but a family or several families of transition curves are obtained (Fig. 10). This is the reason that the experimental evidence could be clearly interpreted only in recent years after the tests had been extended to very high Reynolds numbers. The former tests referred mostly to the transition region and the evidence appeared confused and contradictory.

One practical conclusion results for the aeronautical engineer; drag measurements are of little value if the models are so small or the wind velocity is reduced to such an extent that the Reynolds number falls in the transition region, because the skin friction in such cases is largely influenced by the turbulence conditions in the wind tunnel.

The turbulent friction of the smooth plate appears as a lower limit for the drag of any aircraft and is perhaps at present the greatest impediment to increase of speed. Hence the question arises whether there is any possibility to " cheat nature " and diminish the skin friction in some tricky way. To stabilise the boundary layer up to the Reynolds number used in up-to-date aircraft is hardly feasible. However, it might be possible to prevent the growth of the boundary layer beyond the limit of instability by removing the excess amount of air. The volume of air which has to be removed in time is roughly given by $C_1 SU/2$, where C_1 is the value of the laminar skin friction coefficient which shall be maintained by this artifice, and S is the surface area to be protected against turbulence. If C_1 is identified with the local friction coefficient of the laminar layer immediately before transition into the turbulent régime, its value would be about 0.00115-0.002. Up to the present no practical results are published concerning the feasibility of this method.

The next question is, how far are we able to approach the limit given by the friction of the smooth plate? Here the problem of roughness enters into the picture. Hence, let us summarise the results of recent research on this subject which can be considered as ascertained knowledge:—

(*a*) It appears that the influence of roughness on skin friction is not significant below a certain Reynolds number. The physical reason for this behaviour of a rough surface seems to be that the roughness elements are in this range small

in comparison with the thickness of the laminar sublayer.* It was mentioned that the latter is given by a relation $(\tau/\rho)^{\frac{1}{2}}\,\delta_1/\nu = \text{const.}$ and because the friction itself increases with the Reynolds number, δ_1 decreases if the Reynolds number increases. Hence, with increasing Reynolds number the roughness elements emerge out of the laminar sublayer like a mountain emerges from a layer of fog if the thickness of the latter gradually diminishes (Fig. 11).

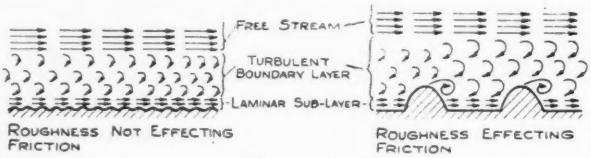


FIG. 11.

Schematic figure for roughness and laminar sublayer.

(*b*) When the height of the roughness elements is large in comparison with the laminar sublayer, apparently the skin friction is given by the total frontal resistance of those elements; correspondingly, beyond a certain Reynolds number the skin friction itself is proportional to the square of the relative velocity between fluid and solid. This limiting case has been studied by various research workers—in particular the pressure drop has been measured in channels with constant cross-section and artificially roughened walls. It was found that for the same absolute roughness (*i.e.*, for identical walls) the skin friction coefficient is proportional to the logarithm of the so-called relative roughness, *i.e.*, of the ratio between the height of the roughness element to the width or diameter of the channel. The skin friction coefficient is given by an equation of the form

$$2/\sqrt{C_f} = A + (1/k)\log(r/h) \quad . \quad . \quad . \quad . \quad (17)$$

or

$$C_f = 4/(A + 1/k \log r/h)^2 \quad . \quad . \quad . \quad . \quad (18)$$

(r = linear dimension, *e.g.*, hydraulic radius of the channel, h = the height of the roughness elements). Equation (17) was first given by the author in 1929. The constant k has sensibly the same value as the constant denoted by the same symbol in the equation (13) for the velocity distribution.

Equation (17) makes it possible to establish a scale for roughness. Evidently, if h is arbitrarily chosen for one kind of artificial roughness—for instance, a certain kind of sand paper—by measuring the skin friction coefficient in a channel and applying equation (17), a definite value of h can be assigned to any kind of surface.

A few important conclusions can be drawn from the results mentioned. First, it is possible to estimate for a given speed and dimensions the thickness of the laminar boundary sublayer and calculate the upper limit of a permissible roughness, *i.e.*, a tolerance inside which, under given conditions the roughness would not influence sensibly the skin friction. It is to be understood that, as far as the relative roughness is concerned, the thickness of the boundary layer plays the same *rôle* as the width of a channel with rough surface walls. Then it is evident that, the skin friction coefficient being a function of the relative roughness, the same roughness will have more influence near the leading edge where the boundary layer is thin than further back, where the boundary layer has a considerable thickness.

The theoretical prediction of the skin friction acting on a surface with a certain roughness is rather difficult. The difficulty is that the relative roughness is

* This assumption was substantiated by a more detailed discussion of the problem by S. Goldstein, R. & M. 1763. He found as criterion, that a roughness element of the height h does not produce any effect on the main flow: $h\sqrt{\tau/\rho}/\nu < \sqrt{R_c}$, where R_c is of the order of $30 \sim 50$.

variable along the surface because the thickness of the boundary layer varies. Hence, it is necessary to compute the growth of the boundary layer, then to calculate the local skin friction coefficient from equation (17) and integrate it along the length of the plate.

Furthermore, we encounter a considerable uncertainty due to the following fact. Equation (17) is correct for large Reynolds numbers. However, the Reynolds number of the boundary layer starts from zero near the leading edge and thus as the boundary layer develops downstream we have to go through the whole range of Reynolds number, especially through a transition range in which the height of the roughness elements and the thickness of the laminar sublayer are of the same order. Plotting the skin friction coefficient as a function of Reynolds number in this range, we obtain a family of similar curves for definite geometrically similar kinds of roughness. However, the curves are different when the geometry of the roughness elements is different. They depend, for instance, on the ratio between the distance of the elements and their height, *i.e.*, on the " relative wave length " of the roughness. Skin friction curves obtained for so-called " wavy " surfaces, *i.e.*, corrugated plates with large wave length do not fit in the family of curves obtained for surfaces with sharp protruding parts. This field is still open to theoretical discussion, and much additional experimental information is needed.

In addition to the research work done in wind tunnels, *e.g.*, in compressed air tunnels, the direct measurement of friction drag in flight, suggested by German researchers and developed especially by B. M. Jones in England to a high degree of accuracy, promises to be very helpful in clearing up this question.

Summarising, it must be admitted that at the present stage of our knowledge the prediction of the actual frictional drag of aeroplane wings and other parts from wind tunnel tests is not quite free from guesswork, especially because of our incomplete knowledge on the subject of roughness.

We have so far considered the turbulent friction of a fluid moving along a solid surface. A few words must now be said about turbulent friction between fluid masses. Prandtl introduced for such cases the name " free turbulence." We shall consider the simplest case only. Let us assume that at time $t=0$, two adjoining fluid masses separated by the plane $y=0$ are put in uniform motion; the initial velocity of the fluid for $y>0$ being equal to $+U$, for $y<0$ being equal to $-U$ (Fig. 12).

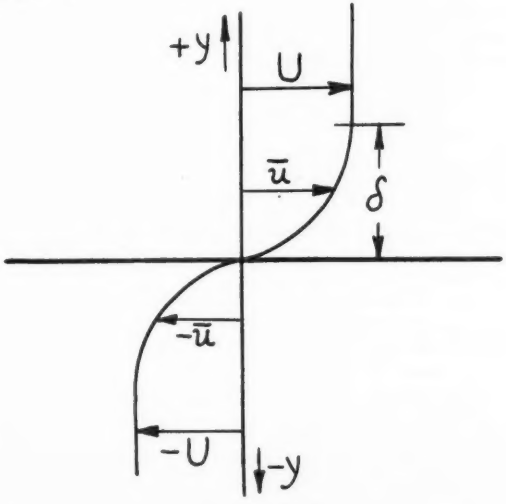


FIG 12.

We assume first, laminar flow. It is not difficult to find the exact mathematical solution; however, the main result can be found from the following simple consideration.

We introduce again the thickness of the boundary layer, which we define by the relation $U\delta = \int_0^\infty (U-\bar{u})\,dy$. Then it is easily seen that the momentum law gives an expression for the friction involving U and δ, and that the energy law determines δ as function of the time. Denoting by τ_0 the shearing stress at $y=0$, the momentum law can be expressed in the form

$$\tau_0 = \alpha\rho U\,(d\delta/dt) \qquad (19)$$

(α being a numerical form factor). The energy law implies that the loss of kinetic energy is equal to the dissipation by the viscous forces. Evidently, the loss of energy is expressed in the form $\beta\rho U'^2\delta$, whereas the dissipated energy is equal to $\gamma\mu \int_0^t (U^2/\delta^2)\,\delta dt$, β and γ are non-dimensional form factors. Hence, it follows from the energy theorem, that

$$(\beta/\gamma)\,\delta = \nu \int_0^t dt/\delta \qquad (20)$$

or

$$\delta^2 = \text{const.}\ \nu t \qquad (21)$$

We found the same result for the steady boundary layer along a plate.

Let us consider now the turbulent case. Except at the very beginning of the process, the viscous forces are very small in comparison with the turbulent stresses. This means that we have to find the loss of kinetic energy of the main flow in the increased kinetic energy of the fluctuations. Hence, if $\frac{1}{2}q^2 = \frac{1}{2}(u'^2+v'^2+w'^2)$ is the average velocity head of the turbulent fluctuations

$$\int_0^\delta (\rho/2)\,(U^2-\bar{u}^2)\,dy = (\rho/2)\int_0^\delta q^2 dy \qquad (22)$$

On the other hand, the loss of momentum during the time t is equal to the impulse of the frictional force τ_0, acting at $y=0$. Hence,

$$\rho\int_0^\delta (U-\bar{u})\,dy = \int_0^t \tau_0 dt \qquad (23)$$

Using again numerical form factors, equation (22) can be written in the form

$$\alpha\rho U^2 = \beta\rho q_0^2 \qquad (24)$$

(q_0 is the value of q at $y=0$) and equation (23)

$$\gamma\rho U\delta = \int_0^t \tau_0 dt \qquad (25)$$

It follows by differentiation (as in the case of laminar friction) that

$$\tau_0 = \gamma\rho U\,(d\delta/dt) \qquad (26)$$

Now τ_0 is the turbulent frictional stress and is equal to $-\rho\overline{uv}$. We denote the mean value of the ratio $-\overline{uv}/q^2$ (the so-called correlation factor of the components u, v) by K_1 and write $\tau_0 = K_1\rho q_0^2$. It is assumed that K_1 is independent of the time. Hence, we obtain from equation (24)

$$\tau_0 = (\alpha/\beta)\,K_1\rho U^2 \qquad (27)$$

taking into account equation (26)

$$d\delta/dt = (\alpha\gamma/\beta)\, K_1 U \qquad . \quad . \quad . \quad . \quad (28)$$

The physical meaning of these equations is that the transition region expands with a constant velocity proportional to the relative speed which initially existed between the two fluid masses. The turbulent friction between the two fluid masses is proportional to the square of the relative speed. It is remarkable that we obtain a definite numerical constant as the friction coefficient between fluid and fluid, whereas the friction coefficient between the fluid and a smooth wall is a function of Reynolds number and tends to zero as $R \to \infty$. We are interested in the numerical value of this friction between fluid and fluid. For the unsteady case we have so far been considering, no experimental evidence is available. However, the results can be transferred to the steady case of friction between two fluid masses which meet at a point with a finite difference between their velocities. If the turbulent mixing process starts at $x=0$, we find that the width of the mixing region is proportional to x (corresponding to t in the unsteady case) and the friction is constant along the x axis. This case has been investigated experimentally; the friction coefficient referred to $\rho U^2/2$ (U = relative velocity of the two streams) is of the order of $C_f = 0.02$. It takes a very rough surface to have a friction coefficient as high as this value. Hence, we find that in general a larger friction exists between fluid and fluid than between fluid and solid (Fig. 13). This fact is illustrated by the well-known paradox that a cylindrical solid body floating in a river with its axis parallel to the flow moves faster than the water itself. The explanation is that if the solid cylinder is replaced by a fluid one, then the turbulent friction is increased instead of decreased.

Friction between fluid and fluid occurs in many practical problems. The question of the gradual decay of the slipstream of a propeller, the spreading out of a fluid jet injected into a fluid, the decay of the wake of a moving body belong to this class of problems. L. Prandtl, Tollmien, Schlichting, and other members of the Göttingen circle gave a semi-empirical theory of such cases based on the concept of momentum transfer. G. I. Taylor and Matteoli treated some of the cases mentioned, starting from different aspects of the turbulence problem. The present writer feels that a satisfactory solution can be reached only by considering the exchange of all mechanical quantities involved, namely, momentum, energy and vorticity. The simple dimensional consideration sketched above might give a starting point for a more complete theory.

5. When Turbulence Works for the Aeronautical Engineer.

While turbulence represents an unwelcome contribution to skin friction, we ought not to forget that streamlining would be practically impossible without the instability of the laminar motion. The concept of the boundary layer brought clearness into two problems; it made us understand the mechanism of skin friction and the mechanism of separation or wake formation. Lord Rayleigh discussed the form drag of a plate based on the theory of discontinuous potential motion developed by Kirchhoff and Helmholtz. In the few cases which have been treated by means of this theory the production of a wake was explained by the presence of sharp edges. It was said that the flow around the edges implies infinite velocities. However, a circular or elliptical cylinder does not have sharp edges; nevertheless, we get separation. The theory of the boundary layer explained this separation of the flow by the presence of an adverse pressure gradient. But it is known that the laminar boundary layer has so little resistance against such an adverse pressure gradient that only sections with very large fineness ratios would enjoy the advantages of the streamline shape. The story how the favourable influence of boundary layer turbulence on form drag was discovered is generally known. It started with a discrepancy between measurements of the drag coefficient of a sphere in Eiffel's laboratory and Prandtl's laboratory. The

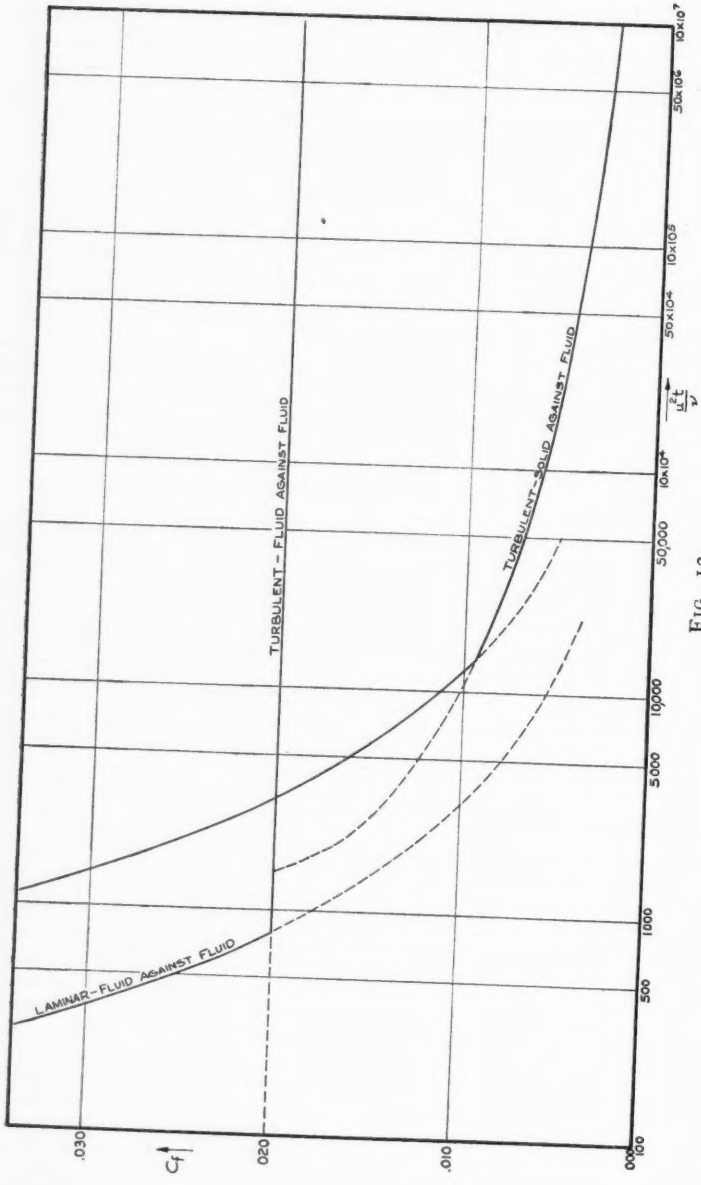


FIG. 13.

Comparison between friction, fluid vs. solid and fluid vs. fluid.

measurements were carried out at different Reynolds number in the two tunnels. Then Eiffel extended his measurements over a wider range, found the sudden decrease of the drag coefficient, which as Rayleigh pointed out always occurred at the same critical Reynolds number. Finally, Prandtl explained the change by the transition from the laminar to the turbulent régime in the boundary layer. Later it was found that the critical value of the Reynolds number depends largely on the degree of turbulence of the wind stream, and indeed it is used as an indication for the degree of turbulence of different wind tunnels.

A similar influence of the turbulence of the wind stream on the stalling of aerofoils was discovered a few years ago. The investigation of this problem started, also, from a discrepancy in experimental results, this time between the measurements in the N.A.C.A. variable density tunnel and in the atmospheric tunnel of the California Institute of Technology. The latter tunnel having a low turbulence level (about 0.4 per cent. velocity fluctuation), the transition between the laminar and turbulent régimes is delayed and stalling occurs at a lower value of the lift coefficient than in a tunnel with a higher turbulence level. By introducing artificial turbulence results obtained in other tunnels could be reproduced. Hence, the lift maxima of an aerofoil appear correlated with the turbulence of the wind stream and are to be considered as functions of at least two parameters—the Reynolds number and the turbulence level. For this reason, H. L. Dryden called turbulence the " companion of Reynolds number."

However, the actual case is even more complex. Turbulence—as will be seen in the next section—is not characterised fully by the turbulent level, *i.e.*, by the relative magnitude of the velocity fluctuations. At least one length, corresponding to the physical extension of the eddying units, must be taken into account in order to describe the effect of outside turbulence on the transition in the boundary layer. In the investigations quoted above, this was clearly shown by the fact that in the experiments carried out in the free atmosphere even bumpy air failed to produce effects similar to those produced by an increased turbulence level in the wind tunnel. In other words, large scale turbulence has quite a different effect from small turbulence. Recently, G. I. Taylor found that the critical Reynolds number R_c ought to satisfy a relation of the form :—

$$R_c = F\,(u/U)\,(D/L)^{1/5},$$

where u is the magnitude of the velocity fluctuations, D is the diameter of the sphere and L a characteristic length for the physical size of the turbulence.

It is seen from this short review of experimental facts that both the transition from the laminar to the turbulent régime and the separation of the turbulent boundary layer have a paramount influence in a number of extremely important phenomena. Recently " tip stalling," connected with an increased taper ratio of wings, brought up again the problem of separation. The following points appear to the present writer as the main points on which we are ignorant :—

(*a*) Influence of curvature and pressure gradient on the transition point;
(*b*) Influence of outside turbulence on the transition point;
(*c*) Influence of curvature and pressure gradient on the separation of a turbulent boundary layer;
(*d*) Influence of roughness on the same characteristics.

The attempts to solve the separation problem by semi-empirical methods developed by Buri and Gruschwitz do not appear very successful. The present writer is convinced that in order to bring clearness into these questions, we have to resort to the basic laws of turbulent exchange.

In one respect we are in a better position than in the case of the molecular exchange phenomena; due to the macroscopic dimensions in which the process takes place, direct observation is easier than in molecular physics. However, as has already been mentioned, the theoretical formulation of the problem is much more difficult; atoms and molecules are definite units which can be disintegrated only by the action of forces of immense concentration. Eddies are

easily born and easily dissipated; hence, their statistical theory requires much more refined methods than, for instance, the kinetic theory of gases.

We are witnessing at present the infant years of the statistical theory of turbulence, its first attempts at making a few steps. However, there is no doubt in my mind that the methods and results of this theory will be included in the practical aerodynamics of the future just as the Lanchester-Prandtl wing theory, and to some extent the boundary layer theory, has been included in the engineering aerodynamics of to-day. For this reason it is perhaps worth while to give a short review of the basic concepts of the statistical method.

6. Turbulence at its Birth, in its Prime and in Decay. The Basic Concepts of the Statistical Theory.

As indicated in the introduction to this paper, turbulence is built up in most cases by the mixing and intermingling of a great number of individual eddies. In recent investigations on the structure of turbulence, both in England and in the United States, screens were used to produce a uniform field of turbulence in wind streams. In this case the kinetic energy of the turbulent fluctuations is produced by the drag of the individual rods or wires of which the screen consists. Immediately behind the rods, in general, individual vortices can be observed; however, these vortices soon disappear and the wind shadows of the rods consist of irregularly eddying fluid. Not very far downstream the individual wind shadows also disappear, and velocity and vorticity fluctuations appear to be uniformly distributed over the whole cross-section of the stream.

If a fluid passes over a surface, turbulence is permanently created by the eddies produced by the roughness of the surface or by the instability of the laminar sublayer. It is remarkable that the trace of the origin of the turbulence is wiped out very soon, *i.e.*, at a rather small distance from the place of the birth of the individual eddies. For instance, in the case of a channel with corrugated walls, we find at a distance as small as about twice the height of the corrugations that the turbulence level is sensibly constant along lines parallel to the main direction of flow, independently of whether the place of observation is over a crest or a valley of the corrugated surface.

The turbulent fluctuations can be measured in different ways—by use of anemometers, such as the hot wire anemometer, suitable for recording rapidly oscillating velocities, or by visual observation. For visual observation we can use foreign particles suspended in the fluid or heated particles of the fluid itself, made visible by the difference in the refractive index. In the free atmosphere or in a river the eddies are in general so large, and consequently the time scale of the fluctuations containing the bulk of the kinetic energy is so slow that the lag of ordinary anemometers, flow meters and recording vanes does not prohibit their use for fluctuation measurements.

Denoting the velocity fluctuations in three orthogonal directions x_1, x_2, x_3, by u_1, u_2, u_3, their mean squares by $\overline{u_1^2}$, $\overline{u_2^2}$, $\overline{u_3^2}$, we define the quantity $\frac{1}{2}(\overline{u_1^2}+\overline{u_2^2}+\overline{u_3^2})$ as the mean kinetic energy of the turbulence per unit mass of the fluid. O. Reynolds pointed out that the velocity heads $\frac{1}{2}\rho\overline{u_1^2}$, $\frac{1}{2}\rho\overline{u_2^2}$, $\frac{1}{2}\rho\overline{u_3^2}$, represent pressure components per unit area perpendicular to the x_1, x_2, x_3 directions, respectively, while the mean values of the products $-\rho\overline{u_1u_2}$, $-\rho\overline{u_2u_3}$, $-\rho\overline{u_3u}$, represent shear stresses; we call them the components of turbulent friction. The six components (pressures and shear stresses) constitute the tensor of the turbulent stresses. The "turbulence level" is characterised by the average magnitude of the square of the velocity fluctuations.

The next thing which we can determine from fluctuation records is the frequency with which a velocity of a given magnitude occurs. It seems from the experimental evidence available that in general the frequency distribution of velocities of different magnitudes corresponds fairly well to the error law (Fig. 14).

The simplest case of a turbulent velocity field is that of the so-called *isotropic turbulence*, first subjected to a systematic study by G. I. Taylor. Isotropic turbulence is defined by the feature that there is no distinction between directions as far as the field of the velocity fluctuations is concerned, *i.e.*, from the point of view of an observer who is moving downstream with the mean motion of the fluid mass observed. Such is the case, for instance, in a uniform artificial wind stream with a constant turbulence level over the cross-section, and, at any rate approximately, in a uniform natural wind at a sufficient height over the ground.

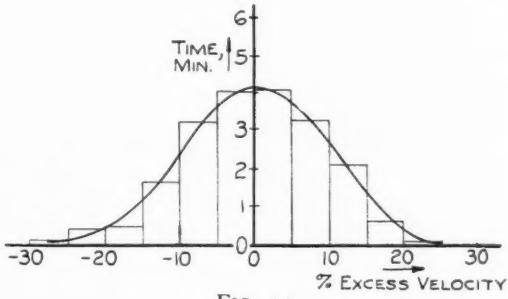


FIG. 14.

Frequency of the occurrence of velocity fluctuations during 20-minute observation time. The abscissæ represents the magnitude of the velocity fluctuation, the ordinate the time t during which the velocity fluctuation is between certain limits. (Observations of A. Knethe, Akron, O.)

Isotropic turbulence is to some extent analogous to the molecular system of a gas at rest. The gas being at rest, all directions are equivalent, and the collisions between the molecules result in three equal pressure components. Shearing stresses are zero. Similarly, in the case of isotropic turbulence, the three normal stresses are equal, and the shearing stresses, which depend on the mean values of products like $\overline{u_1 u_2}$, vanish. Indeed, if $\overline{u_1 u_2}$ were different from zero, the condition of isotropy could not be satisfied. For if we change, for example, the x_2-axis to $-x_2$, the mean value $\overline{u_1 u_2}$ would change its sign, and a distinction could be made between the x_2 and the $-x_2$ direction, in contradiction to the definition of isotropy.

There is, however, the following important difference between a molecular field of a gas in equilibrium and an isotropic turbulent velocity field. Radiation and heat conduction at the walls being neglected, the molecular system is non-dissipative, *i.e.*, the mean kinetic energy of the molecules (which is essentially identical with the heat energy of the gas) remains constant. The eddying fluid is subjected to the permanent action of viscous dissipation, *i.e.*, the turbulence decays and the kinetic energy of the macroscopic unrest which we call turbulence is transformed into the kinetic energy of molecular unrest which we call heat.

The laws of the decay of turbulence due to viscous dissipation is a question both of theoretical interest and of importance for many practical applications in engineering and meteorology. The viscous stresses being proportional to the space derivatives of the velocity components, the dissipation depends both on the turbulence level and on the sub-division of the turbulent field, *i.e.*, on the size of the eddies or, in a more general sense, on the structure of turbulence.

For studying the structure of turbulence, we can use a purely descriptive or a statistical method. A descriptive method, was, for example, by Schmidt and recently by Sherlock in his interesting investigations on the structure of strong winds (gales) (Fig. 15).

The statistical method studies average values and tries to determine the physical size of the eddies by measurements of correlations between velocity components. The statistical method has the advantage that all quantities involved are defined with mathematical exactitude. Individual configurations and events disappear, however, in the averaging process.

What is correlation in general? Let us observe and record the simultaneous occurrence of a certain event at two places A and B; assume the probability that the event will occur or will not occur is the same. Whenever the event occurs we write $+1$ in our records, in the opposite case -1. For

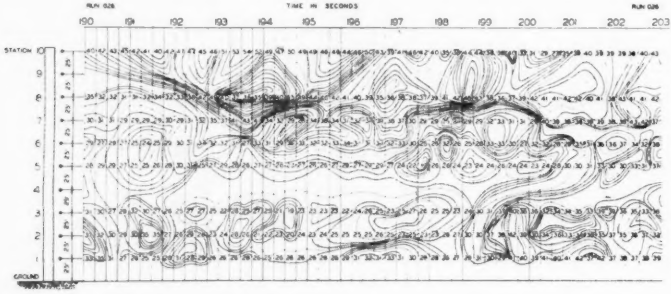


FIG. 15.

Example of analysis of wind structure near the ground by the descriptive method (Sherlock).
Lines of equal velocity as function of height and time.

instance, $a=1$ means that the event occurred at A; $b=1$ means that the same event occurred at B. Then it is evident that if the events at A and B are independent, *i.e.*, non-correlated, the mean value of the product $\overline{ab}$ is equal to zero; if the two events at A and B always occur together $\overline{ab}=1$, and if exactly the opposite is true, then $\overline{ab}=-1$. If there is a partial link between the events at A and B, *i.e.*, a "correlation," $0<|\overline{ab}|<1$. It is evident that in the same way also a correlation between two events of different kinds at A and B can be measured.

Let us assume now that we measure two arbitrary velocity components u_i and u_k at two different points of an isotropic turbulent field. In order to find out whether the fluctuations at A and B are correlated we build the average values of the products $\overline{u_{iA}u_{kB}}$, which we denote by q_{ik}. Obviously, considering A and B as fixed points, there are nine such values, of which three pairs are numerically equal because of the equivalence of all directions, *e.g.*, $\overline{u_{iA}u_{kB}}=\overline{u_{kA}u_{iB}}$, *i.e.*, $q_{ik}=q_{ki}$. As regards the remaining six quantities, in a uniform field of large extension, we can choose A arbitrarily, and the quantities q_{ik} will be functions of the position of B. If we choose A as origin of a co-ordinate system x_1, x_2, x_3, the q_{ik} will be functions of x_1, x_2, x_3. If the distance between A and B, *i.e.*, the radius $r=\sqrt{(x_1^2+x_2^3+x_3^2)}$ is large, the mean values are very small—in fact, they practically vanish. If A and B coincide ($r=0$), the mean values q_{11}, q_{22}, q_{33} are equal to $\overline{u^2}$, where $\overline{u^2}$ is the common mean values of $\overline{u_1^2}$, $\overline{u_2^2}$ and $\overline{u_3^2}$, and $q_{12}=q_{23}=q_{31}=0$, because, as was indicated above, the shear stresses vanish.

Dividing the six quantities q_{ik} by $\overline{u^2}$, we define the ratios $q_{ik}/\overline{u^2}$ as the correlation functions R_{ik}. In the case of isotropy the six correlation functions R_{ik} can be expressed in terms of two functions $R_1(r)$ and $R_2(r)$. The first of these functions is the correlation between the velocity components in the direction

of the straight line AB, which connects the two points of observation A and B; the second function is the correlation between the velocity components perpendicular to AB and parallel to each other. We call R_1 the longitudinal, R_2 the transverse correlation. If the fluid is considered incompressible, R_1 and R_2 are connected by the continuity relation

$$dR_1/dr + 2(R_1 - R_2) = 0 \quad . \quad . \quad . \quad . \quad (29)$$

This relation can be used as a check on the isotropic character of a turbulence field. The measurements of Simmons show that in the cases investigated in the N.P.L. wind tunnel the relation was very closely satisfied (Fig. 16).

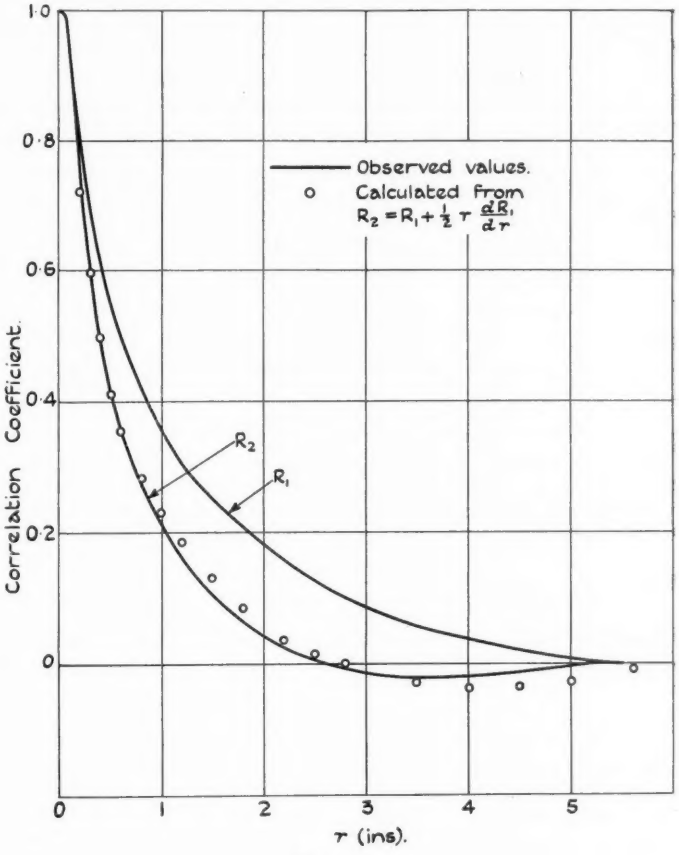


FIG. 16.

The relation between longitudinal and transverse correlation, measurements of Simmons (N.P.L.).

If we imagine that turbulent motion consists of the random motion of a great number of coherent air masses—" gusts " or " eddies "—the " width " of the correlation curve gives us an idea of their size. Take, for instance, the longitudinal correlation curve R_1 in Fig. 16. For $r = 1$ inch we find $R_1 = 0.36$. This means that there is a relatively large probability that two fluid particles one inch

apart move in the same direction. We conclude that a considerable number of eddies of this dimension must exist in the flow observed by Mr. Simmons, because if all eddies would be much smaller than one inch, the motion of the particles would be independent and the correlation near to zero. Hence the comparison of correlation curves observed under different conditions gives at least a relative measure of the " physical size " of turbulence.

The curvatures of the correlation curves at their peaks, *i.e.*, at $r=0$, has special significance because the squares and products of the first derivatives of the velocity fluctuations depend only on their magnitude, *i.e.*, on the values of d^2R_1/dr^2 and d^2R_2/dr^2 at $r=0$. Let us consider, for instance, the value of $(\partial u_1/\partial x_2)^2$. We are interested in such mean values because the sum $\Sigma\mu\,(\partial u_i/\partial x_k)^2$ represents the work done by the viscous stresses per unit time, *i.e.*, the rate of dissipation of the kinetic energy of the turbulence by viscosity. Now

$$\overline{(\partial u_1/\partial x_2)} = \lim.\ \overline{(\bar{u}'_1 - \bar{u}_1)^2}/(x'_2 - x_2)^2,$$

provided that $\bar{u}_1$ is the value of the fluctuation of the velocity at the point x_2 and $\bar{u}'_1$ at the point x'_2 and the limit means $x'_2 \to x_2$. Carrying out the calculation, we obtain

$$\overline{(\partial u_1/\partial x_2)^2} = \lim.\ (\overline{\bar{u}'_1{}^2} + \overline{\bar{u}_1{}^2} - 2\overline{\bar{u}'_1\bar{u}_1})/(x'_2 - x_2)^2$$

and because $\overline{u'_1{}^2} = \overline{u_1{}^2}$ and $\overline{u_1 u'_1} = R_2\overline{u^2}$, the mean value

$$\overline{(\partial u_1/\partial x_2)^2} = 2\bar{u}^2\ \{\,(1 - R_2)/(x'_2 - x_2)^2\,\}\ .$$

We now develop the correlation function in powers of the distance $x'_2 - x_2 = r$ and write

$$R_2 = 1 + \tfrac{1}{2}\,(d^2R/dr^2)_0\, r^2 + \ \ldots$$

Then evidently

$$2\,(1 - R_2) = -\,(d^2R_2/dr^2)\, r^2 - \ \ldots$$

and going to the limit $r=0$, $(x'_2 \to x_2)$,

$$\overline{(\partial u_1/\partial x_2)^2} = 2\bar{u}^2\ (d^2R_2/dr)_0.$$

G. I. Taylor suggested a simple geometrical representation for $(d^2R_2/dr^2)\,r=0$. If we approximate to the curve $R_2\,(r)$ in the neighbourhood of its peak by a parabola, writing $R_2 = 1 - r^2/\lambda^2$, then λ is the distance between the origin and the point of intersection of the parabola and the r-axis. Evidently

$$\tfrac{1}{2}\,(d^2R_2/dr^2)_0 = -\,1/\lambda^2,$$

and we obtain

$$\overline{(\partial u_1/\partial x_2)^2} = \overline{u^2}/\lambda^2.$$

Carrying out similar calculations for the rest of the term of the dissipation function $\Sigma\mu\,\overline{(\partial u_i/\partial x_k)^2}$, we obtain the fundamental equation for the decay of turbulence

$$\overline{dg^2}/dt = -\,10\,\nu\,(g^2/\lambda^2) \qquad . \quad . \quad . \quad . \quad (30)$$

where $g^2 = \overline{u_1{}^2} + \overline{u_2{}^2} + \overline{u_3{}^2}$, *i.e.*, twice the mean turbulent kinetic energy of unit mass of the fluid, ν = the kinematic viscosity and λ is a length characteristic of the steepness of the velocity gradient in the turbulent flow; Taylor calls λ the size of the " smallest eddies "; the exact definition of λ was given above.

The attention of researchers working at present on the fundamentals of the statistical theory is concentrated on the proper evaluation of the equation (30). The length λ was called by Taylor " the linear size of the small eddies," while the width of the correlation curves—as shown in Fig. 16—gives the average size of the " large " eddies. The main question is, what determines the further development of the eddy dimension λ? If we imagine a turbulent field such that λ is constant, then the energy would disappear rather rapidly, and in proportion to an exponential function of the time. It seems in general that λ increases with the time because the small eddies die out faster than the large ones. Due to this process, it is probable that λ^2 increases in proportion to the time, so that the energy itself is proportional to some negative power of the time. However, no

definite answer has yet been reached, and the problem is still open to discussion.

A similar idea can be applied to the dissipation of the mean vorticity of the fluid. Denoting the three components of the vorticity vector by ω_1, ω_2, ω_3, it can be shown that the quantity $\omega^2 = \overline{\omega_1}^2 + \overline{\omega_2}^2 + \overline{\omega_3}^2$ satisfies the following equation:—

$$d\omega^2/dt = -10\,\nu\,(\omega^2/\lambda_w^2) + \overline{\omega_l \omega_k\,(\partial u_l/\partial x_k)} \quad . \quad . \quad . \quad (31)$$

where $\lambda\omega$ is a length analogous to λ, characterising the space variation of the vorticity fluctuations.

The first term on the right-hand side represents the dissipation of the vorticity by the friction; the second term represents the change of the mean vorticity due to changes in the shape of the eddies. Let us consider, for instance, a finite part of a vortex tube like the central part of a tornado. If the fineness ratio of such a cylinder increases the mean vorticity also increases; if the cylinder becomes shorter, the mean vorticity decreases. Is there any tendency in one direction or the other in a random turbulent motion? The answer to this and to other similar questions will decide the final form of the fundamental equations for turbulent flow.

The experimental investigation of the correlation functions is of great importance not only for the development of the theory, but also for many applications in meteorology, oceanography, hydraulics and other fields of engineering.

The figures 17-21 give a few examples of the distribution of the magnitude of velocity fluctuations, and of the correlation functions, measured in a wind tunnel, in a river (Mississippi), and in the free atmosphere.

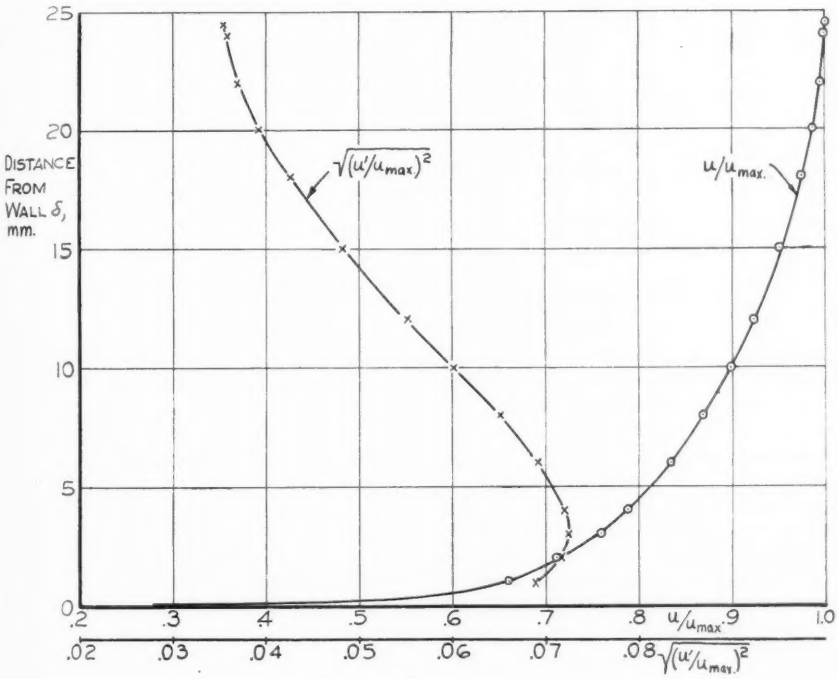


FIG. 17.

Distribution of the mean velocity and the velocity fluctuation in a wind tunnel of rectangular cross-section with large aspect ratio.
(Measurements of Wattendorff and Knoblock, Cal. Inst. of Techn.)

An immediate engineering application of correlation measurements is to give an estimate of the size of gusts acting on an aeroplane or airship or on a part of thereof. If the size of the aireraft is small in comparison with the size of the gusts, it can be assumed that the relative velocity and angle of attack are variable with time, but practically constant over the span or length of the aircraft. However, this is certainly not true for airships, and also probably not true for the largest land- and seaplanes built at present. Then both for establishing gust factors for structural safety, and for studying the dynamical effects of gusts, certain assumptions of probable load distributions are necessary. Correlation measurements and the statistical analysis of gusts might give a sound basis for such considerations, in a way analogous to the standard wave forms used in naval engineering.

The concept of the correlation also plays a paramount *rôle* in the understanding of the process of turbulent exchange, which, after all, remains the main objective of theoretical and experimental research on turbulence. In our preliminary con-

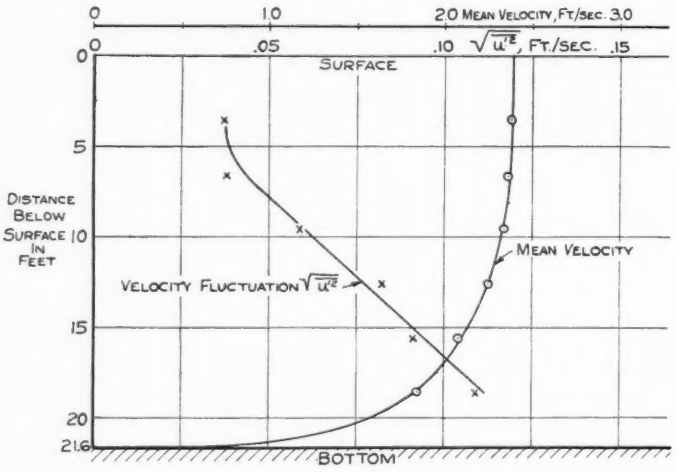


FIG. 18.

Distribution of the mean velocity and the velocity fluctuation in the Mississippi River. (Calculated from records of the U.S. Army Engineers, 1879, only slow fluctuations of the velocity are recorded.)

siderations we assumed that the general law which determines molecular diffusion is also valid, with increased coefficients, for turbulent or eddy diffusion. The molecular diffusion law is based on the fact that the mean square of the distance reached by the particles increases linearly with the time. Applying this law to the case of the so-called Brownian movement, *i.e.*, to the random motion of particles suspended in a fluid, Einstein has shown that the diffusion coefficient of the particles is equal to the quantity $S^2/2t$, where S^2 is the mean square of the distance reached by the particles in time t.

However, if we investigate the problem exactly, we find that the law is only approximate and fails for very small values of the time of observation. The following consideration is due to Langevin and will be reproduced here, because I believe it helps in the understanding of our present problem.

We consider the average motion of a great number of particles and calculate the value of S^2, *i.e.*, the mean value of the square of the distance which the

particles reach in a certain direction during a certain time interval t. The differential equation of the motion is

$$d^2S/dt^2 = P/m - (K/m)\,(dS/dt) \quad . \quad . \quad . \quad (32)$$

where P are random forces and $-(K\,(dS/dt)$ is the frictional drag on the particles. Now multiply both sides of the equation by S and take average values for a large number of particles; then if the value and sign of P varies at random, there will be no correlation between P and S and the mean value $\overline{PS}$ vanishes. On the other hand, it is seen by differentiation that

$$S\,(d^2S/dt^2) = (d^2/dt^2)\,(S^2/2) - (dS/dt)^2,$$

hence we obtain the relation

$$(d^2/dt^2)\,(\overline{S^2}/2) = \overline{(dS/dt)^2} - (K/m)\,\overline{S\,(dS/dt)} \quad . \quad . \quad (33)$$

or

$$(d^2/dt^2)\,(\overline{S^2}/2) = \overline{(dS/dt)^2} - (K/m)\,(d/dt)\,(\overline{S^2}/2) \quad . \quad . \quad (34)$$

Let us now assume that the mean value $\overline{(dS/dt)^2}$, *i.e.*, the mean square of the velocity component in the S direction, is constant and equal to $\overline{u^2}$. Then the equation can be solved for $\overline{S^2}/2$, and we obtain

$$\overline{S^2}/2 = Ae^{-Kt/m} + B + (\overline{m}u^2/K)\,t \quad . \quad . \quad . \quad (35)$$

or, because $\overline{S^2} = 0$ and $\overline{dS^2/dt} = 0$ at $t = 0$

$$\overline{S^2}/2 = (\overline{m}^2u^2/K^2)\,(e^{-Kt/m} - 1) + \overline{m}u^2t/K \quad . \quad . \quad . \quad (36)$$

Now let us introduce the characteristic time $t_0 = m/K$; it is equal to the time in which the frictional drag reduces the speed of a particle to the $1/2.73$ part of its initial value.

Then equation (36) reads

$$\overline{S^2} = 2\bar{u}^2t_0^2\,(e^{-t/t_0} - 1) + 2\bar{u}^2tt_0 \quad . \quad . \quad . \quad (37)$$

Let us assume now that $t << t_0$. Then

$$S^2 = u^2t^2 + \text{higher terms} \quad . \quad . \quad . \quad . \quad (38)$$

i.e., S^2/t increases in proportion to the time t. On the other hand, if $t >> t_0$

$$S^2 \cong 2u^2t_0t \quad . \quad . \quad . \quad . \quad . \quad (39)$$

or

$$\overline{S^2}/t \cong 2u^2t_0 \quad . \quad . \quad . \quad . \quad . \quad (40)$$

In the case of the Brownian motion the frictional drag of the particles is so large that t_0 is always smaller than 10^{-5} sec. and only the second case is of practical interest.

However, if we transfer the idea of this investigation to our case—the Brownian motion of large eddies in a turbulent field—the time t_0 in which the eddy loses its velocity or its existence is large (for instance, $100 \sim 1{,}000$ sec. in the case of atmospheric turbulence) and we actually observe both phases of the diffusion process.

It was G. I. Taylor who first showed, based on experiments carried out at the Bureau of Standards, that the temperature distribution in the wake of a point source of heat placed in a turbulent air stream does not follow the law $\overline{S^2} \sim t$, but that after subtraction of the amount corresponding to molecular heat conduction, the rest of the heat is transferred according to the law $S \sim t$. Thus the boundary of the wake defined so as to include a certain percentage of the heat transferred, forms a cone instead of a paraboloid. This is easily seen physically if we imagine that the heat is carried by eddies, the dimensions of which might be large in comparison to those of the heat source; these large eddies will carry the amount of heat which they have picked up practically with constant velocity. The classical type of diffusion, which corresponds to our model used in the first section of the paper, occurs after the first eddy is slowed down or dissolved,

and the velocities of the air particles carrying the heat undergo a large number of changes in direction and magnitude.

This second type of diffusion must, however, occur both at a large distance from the source and also in cases in which friction or heat is transferred between parallel or nearly parallel fluid layers and the mean motion of the fluid is steady or slowly variable.

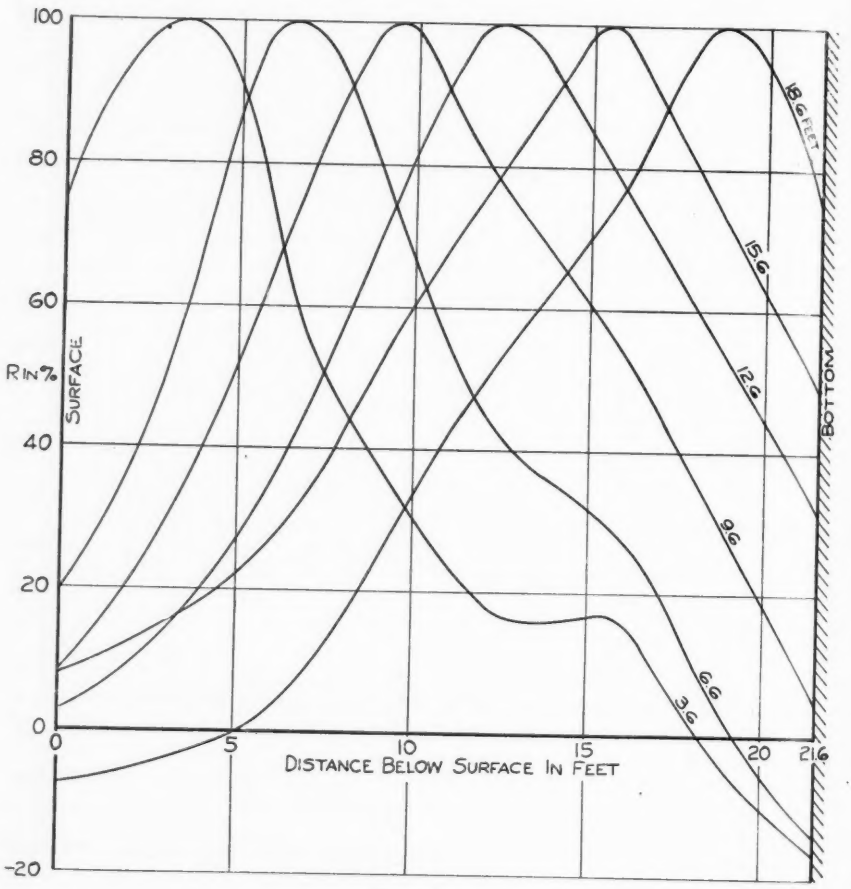


FIG. 19.

River. (Calculated from records of the U.S. Army Engineers, 1879, only the Mississippi River. (Calculated from the same records as Fig. 18.)

It seems to the present writer that the phenomena of the so-called free turbulence—for instance, the development of a transition region between fluid masses having different velocities—correspond to the first class of turbulent diffusion, whereas the case of stationary flow between solid walls, and the case of the flow in the boundary layer, belong to the second class.

The following remarks refer to the steady flow near to a solid surface.

Equation (40) shows that the value of $\overline{S^2}/t$ is determined by u^2 and by t_o. The quantity $\overline{u^2}$ is given by the turbulence level; the main difficulty is the interpreta-

tion of t_o. It is believed that the time t_o, which indicates the lifetime of the eddies, must be connected in some way with the characteristics of the turbulence itself. If we assume that the lifetime is limited by viscous forces, the most reasonable assumption is that t_o is proportional to λ^2/ν, where λ is the size of the small eddies and ν the kinematic viscosity.

The viscous forces acting on a fluid element of the linear dimension λ are indeed proportional to $\mu u\lambda$ (Stokes's law); the mass of the same element is proportional $\rho\lambda^3$; hence the deceleration is proportional to $\nu u/\lambda^2$ and the lifetime to λ^2/ν. Then the diffusion coefficient will be proportional to $(\lambda^2/\nu)\,\bar{u}^2$. The same result is obtained by calculating the time of the decay of a vortex by viscosity.

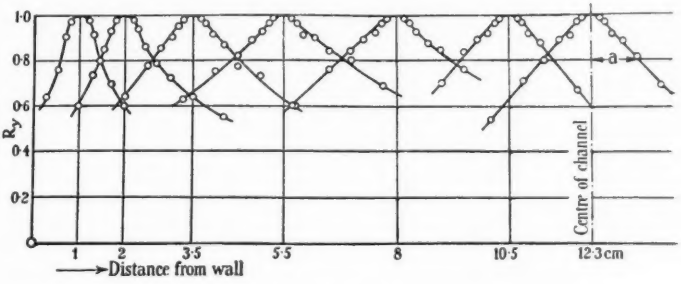


FIG. 20.

Correlation between velocity fluctuation at different points of a wind tunnel with rectangular cross-section (after Göttingen measurements, plotted by G. I. Taylor).

Let us compare this assumption with the so-called "mixing length theory" of turbulence introduced and sponsored principally by Prandtl. We can introduce the concept of the mixing length in our consideration by identifying ut_o with the mixing length l. Then with $t_o=\lambda^2/\nu$ the mixing length would be proportional to $\lambda^2/\nu\,u$. This result can be substantiated by the following simple consideration. Let us assume pure shear motion in which a constant amount of momentum is transferred per unit time from layer to layer. In such a case it is reasonable to assume that every sheet of unit thickness dissipates the work done by the turbulent friction. Taylor has shown that the dissipation of kinetic energy can be written in the form const. $\times\, u^2/\lambda^2$. Then the energy balance is satisfied if

$$\tau\,(dU/dy)=\text{const.}\;\rho\nu\,(u^2/\lambda^2) \quad . \quad . \quad . \quad . \quad (41)$$

where τ is the shearing stress and dU/dy the slope of the mean velocity. On the other hand, the exchange coefficient being proportional to lu

$$\tau=\text{const.}\;lu\rho\,(dU/dy) \quad . \quad . \quad . \quad . \quad (42)$$

Eliminating dU/dy, and taking into account that $\tau=$const., we obtain the relation $l=\text{const.}\;(\lambda^2/\nu)\,u$.

Let us apply these considerations to the shear flow near a wall, such as occurs in the case of the boundary layer. In this case we know from experiment that $dU/dy=(1/\kappa)\,(\tau/\rho)^{\frac{1}{2}}\,(1/y)$, where $y=$distance from the wall and κ is a universal numerical constant. We believe that this general distribution law is due to the fact that the mechanism of the turbulent exchange remains similar if we vary the distance y. In terms of the statistical theory this means that the correlations between velocity components are identical. The shearing stress τ being equal to $-\rho\overline{uv}$ (u,v are the components of the velocity fluctuation in the directions x and y), it follows from the principle of similarity, that $\overline{uv}/\overline{u^2}=$const., or $\tau=\text{const.}\;\rho\overline{u^2}$. Hence it follows from equation (41) that $(dU/dy)\,(\lambda^2/\nu)=$const. or

$$\lambda^2=\text{const.}\;\nu y/(\tau/\rho)^{\frac{1}{2}}.$$

Thus the general picture can be described as follows:—The size of the small eddies increases with the square root of the distance from the wall. The mixing length itself is proportional to the distance; the latter quantity is independent of the Reynolds number, whereas the magnitude of λ depends on ν and $(\tau/\rho)^{\frac{1}{2}}$, and decreases with increasing Reynolds number. In other words, the structure of the turbulent field becomes finer and finer with increasing speed.

The next objective of the theory would be the prediction of the turbulence level and the distribution of mean velocity in a parallel channel, based on similar considerations. Then the influence of curvature, divergence and convergence, variable density, etc., should be included in the general equations.

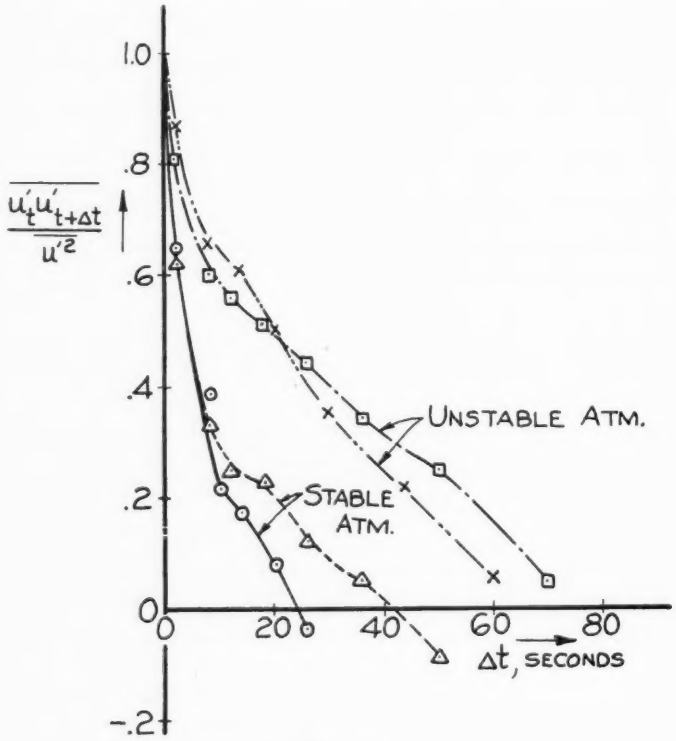


FIG. 21.

Correlation between the velocity fluctuation at a fixed point at different instants. This "time correlation" is a fair approximation for the longitudinal space correlation. Measurements of A. Kuethe in the free atmosphere.

No theory is yet so far advanced that the distribution of mean velocity and of the turbulence level can be predicted or calculated in such cases. Practically every scientist who has become interested in the turbulence problem has formed his own theory of the turbulence exchange; Prandtl's momentum transfer theory and Taylor's vorticity transfer theory are the best known examples. Matteoli offered a combination of both and Gebelein tried to solve the problem by looking at it from the high tower of the general theory of probability; I am afraid that this tower is too high for seeing the simple facts. Wehrle and his collaborators made a highly interesting attempt to apply the principle of the maximum of the

probability in order to deduce general equations for certain class of turbulent flow. Because I, myself, have a theory in the making, I shall refrain from a criticism of the existing theories. I certainly hope that theoretical and experimental research will advance in the next few years so far that agreement will exist concerning the fundamental relations; their full mathematical exploitation and application to special cases may remain for those who come after us.

Many engineers to-day may consider the problem of turbulence merely as an interesting chapter of mathematical physics. They may be right. However, they should remember that if we meet a practical question in aerodynamic design which we are unable to answer, the reason that we are unable to give a definite answer is almost certainly that it involves turbulence. Hence, I believe that in spite of the complex mathematical and physical aspect of the problem of turbulence, the scientist is justified in saying to the practical engineer: *Tua res agitur* (your case is on trial).

It was the principal aim of my lecture to show this.

Prof. R. V. Southwell, F.R.S., F.R.Ae.S.: He had been entrusted with the very pleasant duty of proposing a vote of thanks to Professor von Kármán. Perhaps he could best begin by saying that nobody need hesitate to support this motion because he was conscious that he had not followed every word. Colonel Moore-Brabazon, who usually took on this duty on the occasion of the Wilbur Wright lectures, was accustomed to begin by congratulating the audience on the intelligence of its expression. In that we were only following our public men and the technique they had devised in these days of photographic papers, when it was permissible to be taken with almost any expression (as the young lady said in Anita Loos' novel, "You can register joy, grief or indigestion"), but one must not register perplexity! He, personally, was prepared to confess that at times he had foundered, he would whisper that here and there even Mr. Handley Page—who was to follow him—had been out of his depth; if in a moment he denied it the audience would be well advised not to believe him!

A German scientist whose name he had forgotten once remarked that he would be content when his time came to die happy, if by that time he had understood either the turbulence problem or the new quantum mechanics; by this he imagined the German scientist meant that these are the two hardest problems that confront modern physics. And an English physicist had told him that the difference between the new modern quantum mechanics and the old classical mechanics is this, that in the new quantum mechanics it is permissible to cheat once. Deprived of this permission to cheat once, an investigator is led by Newton's laws to ineluctable conclusions; whereas, evidently, if allowed to cheat more than once, anyone could arrive at anything. He felt that the same was true, in a way, of the turbulence problem; he would not say that the investigator was allowed to cheat, but he was given one bisque—one appeal to experimental fact previously ascertained. He knew of no one who could use his bisque better than Professor von Kármán; the literature relating to turbulence was full of his contributions—and would have been fuller (Professor Southwell had heard) were it not for an idiosyncrasy which caused him to have his brightest ideas sitting in Continental beer-cellars. Having no paper handy he made his calculations on the pseudo-marble top of the beer table; in would come a friend whose conversation started a new idea, and with that new idea they would turn to fresh beer-cellars and virgin tables; and later on a third professor, less original and less scrupulous, would come into the first cellar and find the unfinished calculations; these he would then finish off and publish as his own work!

All this, said Professor Southwell, might seem frivolous considering the occasion, but that was the way he was accustomed to think of Professor von Kármán; not only as a great savant, but also as an indispensable companion at that business of international congresses which is not unconnected with the motion of fluids,

but is best conducted away from the Council Chamber. He had first come across the name of Professor von Kármán in 1912, when with great pride he had published his first paper, only to find he had been forestalled by the Kármán-Engesser theory of struts. Then in 1924 he had met him face to face, when the old town of Delft was shaken and perplexed by what G. K. Chesterton would have called "the horrific and tremendous mystery of the half-brick and of Professor G. I. Taylor's trousers." (Loud laughter.) And his last memory went back two years to Ann Arbor, when he saw Professor von Kármán doing what he thought had never been done in public before, viz., keeping a cigar and a cigarette going simultaneously at full blast.

So, Professor Southwell said in conclusion, he hoped Professor von Kármán would not think he was being treated disrespectfully, because so far as is consistent with affection he did really hold him in reverence. It was with sincerity, and with complete confidence that the motion would be accepted, that he proposed a hearty vote of thanks to him for his lecture.

Mr. F. HANDLEY PAGE, C.B.E., F.R.Ae.S., *Vice-President*: He believed that the large audience would have been even larger if Professor von Kármán could have given his lecture with a marble top table in front of him in the more pleasant surroundings, dare he say, of a beer garden, because then, whilst the lecture was being given, they could all have studied some of the problems of turbulence connected with the motion of liquids! Personally, he said, he remembered this subject of turbulence particularly in connection with the lecture given by Professor Taylor, who distinguished between a state of perfect turbulence and one that was a complete calm. It had always impressed him that perhaps behind the whole theory of turbulence there might be some particular device which to even the high-brow scientists was still unknown. The Society was very fortunate in having Professor von Kármán to give this lecture on the Silver Jubilee anniversary of the Wilbur Wright lectures, for this was the 25th anniversary of the commencement of those lectures. At the same time, he would not like Professor von Kármán to go away thinking that 25 years was a long period in the history of the Society. The Society went back, he believed, some 70 years, but it was very encouraging that after 70 years of existence they could have a lecture on turbulence because it showed the Society was very virile still. At the same time, he well remembered, and would remind Prof. von Kármán, that one of our old archbishops was called the turbulent priest, and he believed it was Thomas a'Becket who paid with his life for being turbulent. He hoped, however, that Professor von Kármán, having demonstrated some of the principles of the subject of turbulence, would not meet with death as the result, not at the hands of the aircraft industry, but perhaps at the hands of the Air Minister.

The Society, continued Mr. Handley Page, owed Professor von Kármán a very great debt of gratitude not only for the lecture he had given that evening, but for his many contributions to aeronautical science. Those who dug deep into the foundations of any science laid the basis for the practical people who came along afterwards, perhaps many years afterwards. It might be that many years would elapse before everybody fully realised the implications of what the scientist had done and therefore it was a very great privilege to be able to second the motion for a very hearty vote of thanks to Professor von Kármán for his lecture.

The vote of thanks was given with hearty acclamation.

The PRESIDENT: He was not going to ask Professor von Kármán to make another speech in reply to those which had been made because he had spoken a good deal already. He had, however, kindly undertaken to demonstrate to the Council in another place the right use of the marble top tables to which Professor Southwell referred and it was about time they started!

The lecture was followed by the Annual Council Dinner at which the following were present:—

Mr. H. E. Wimperis, C.B., C.B.E., F.R.Ae.S., President, in the chair.

Major B. F. S. Baden Powell, F.R.A.S., F.R.Met.Soc., Hon. F.R.Ae.S.
Professor L. Bairstow, C.B.E., F.R.S., F.R.Ae.S. (Zaharoff Professor of Aeronautics, Imperial College).
Major G. P. Bulman, O.B.E., B.Sc., M.I.A.S., F.R.Ae.S. (Assistant Director (Engines) of Research and Development, Air Ministry).
Dr. H. Roxbee Cox, B.Sc., D.I.C., F.R.Ae.S. (Principal Scientific Officer, Royal Aircraft Establishment).
Mr. W. C. Devereux, F.R.Ae.S. (Managing Director of High Duty Alloys, Ltd.).
Mr. A. H. R. Fedden, M.B.E., M.I.A.E., M.S.A.E., F.R.Ae.S. (Chief Engineer, Bristol Aeroplane Company, Limited).
Sir Alexander Gibb, G.B.E., C.B., F.R.S. (President, Institution of Civil Engineers).
Mr. A. Gouge, B.Sc., F.R.Ae.S. (Director, Chief Designer and Chief Engineer, Short Brothers, Limited).
Commander W. K. Harrill (Assistant Naval Attaché for Aviation, American Embassy).
Professor F. T. Hill, F.R.Ae.S., M.I.Ae.E. (Assistant Professor of Aeronautics, Imperial College of Science and Technology).
Professor G. T. R. Hill, M.C., M.Sc., M.I.Mech.E., F.R.Ae.S. (Professor of Engineering, University College).
Mr. J. E. Hodgson, Hon. F.R.Ae.S. (Honorary Librarian, Royal Aeronautical Society).
Professor Th. von Kármán (Guggenheim Aeronautical Laboratory, California Institute of Technology).
Colonel E. E. B. Mackintosh, D.S.O. (Director, Science Museum).
Mr. W. O. Manning, F.R.Ae.S.
Major R. H. Mayo, O.B.E., M.A., A.M.Inst.C.E., F.R.Ae.S.
Mr. F. Handley Page, C.B.E., F.R.Ae.S. (Managing Director, Handley Page, Limited) (Vice-President).
Professor A. J. Sutton Pippard, M.B.E., D.Sc., M.Inst.C.E., F.R.Ae.S. (Professor of Civil Engineering, City and Guilds Engineering College).
Dr. N. A. V. Piercy, M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., M.Cons.E. (Head of Aeronautical Department, Queen Mary College).
Captain J. Laurence Pritchard, Hon. F.R.Ae.S. (Secretary, Royal Aeronautical Society).
Mr. D. R. Pye, C.B., F.R.S., M.A., Sc.D., M.I.Mech.E., F.R.Ae.S. (Vice-President) (Director of Scientific Research, Air Ministry).
Lieut.-Colonel M. F. Scanlon (Assistant Military Attaché for Aviation, American Embassy).
Lord Sempill, A.F.C., F.R.Ae.S.
Lieut.-Colonel Sir Francis Shelmerdine, C.I.E., O.B.E., F.R.Ae.S. (Director General of Civil Aviation, Air Ministry).
Mr. H. O. Short, F.R.Ae.S. (Managing Director, Short Brothers, Ltd.).
Sir Frank Smith, F.R.S. (President, Royal Society).
Professor R. V. Southwell, M.A., F.R.S., M.I.Mech.E., F.R.Ae.S. (Engineering Laboratory, Oxford).
Sir Henry Tizard, K.C.B., C.B., A.F.C., F.R.S., F.R.Ae.S. (Rector of Imperial College of Science and Technology).
Mr. C. C. Walker, A.M.Inst.C.E., F.R.Ae.S. (Chief Engineer and Director of De Havilland Aircraft Co., Ltd.).
Major C. E. Williams, C.B.E.
Mr. L. A. Wingfield, M.C., D.F.C., A.R.Ae.S.I. (Solicitor to the Royal Aeronautical Society, Clerk to the Guild of Air Pilots and Air Navigators of the British Empire).

ABSTRACTS FROM THE SCIENTIFIC AND TECHNICAL PRESS.

Issued by the

Directorates of Scientific Research and Technical Development, Air Ministry.

(Prepared by R.T.P.)

No. 49. November, 1937.

Notes on the Lift and Moment of a Plane Aerofoil which Touches the Ground with its Trailing Edge. (S. Tomotika and I. Imai, Aer. Res. Inst., Tokio, Report No. 154, July, 1937.) (49/1 Japan.)

In the theoretical part of his interesting paper on the interference effect of the ground under the aerodynamical characteristics of a plane aerofoil, G. Dätwyler has calculated the lift and moment of the aerofoil when it touches the ground with its trailing edge.

It is easily seen, however, that Dätwyler's case is a limiting case of our general case treated in detail in our previous papers when the distance (s) of the trailing edge of the aerofoil from the ground becomes indefinitely small. Thus, it is expected that Dätwyler's results can be deduced from our general formulæ as their limiting forms by making $s \to o$.

In the present paper, the limiting forms of our general formulæ are obtained when the trailing edge of the aerofoil approaches indefinitely close to the boundary wall and it is shown that those limiting formulæ are in accord with Dätwyler's formulæ, as we have expected. In this connection it may be remarked, however, that although Dätwyler has obtained the expression for the moment of fluid pressure in terms of certain definite integrals and the values of those integrals have been obtained by means of a planimeter, yet those integrals can be evaluated exactly if we make use of the method of complex integration.

As an addendum, Dätwyler's results are re-obtained by applying the well-known Blasius's formulæ. Also some numerical calculations are carried out and the results are shown in table and figures.

Fuselage Drag Tests in the Variable Density Wind Tunnel: Streamline Bodies of Revolution, Fineness Ratio of 5. (I. H. Abbott, N.A.C.A. Tech. Note, No. 614, Sept., 1937.) (49/2 U.S.A.)

Results are presented of drag tests of six bodies of revolution with systematically varying shapes and with a fineness ratio of 5. The forms were derived from source-sink distributions, and formulæ are presented for the calculation of the pressure distributions of the forms. The tests were made in the N.A.C.A. variable-density tunnel over a range of values of Reynolds number from about 1,500,000 to 25,000,000. The results show that the bodies with the sharper noses and tails have the lowest drag coefficients, even when the drag coefficients are based on the two-thirds power of the volume. The data show the most important single characteristic of the body form to be the tail angle, which must be fine to obtain low drag.

The Influence of a Thin Film on the Movement of Waves. (R. Merigoux, Comp. Rend., Vol. 205, No. 2, 12/7/37, pp. 115-117.) (49/3 France.)

The author shows that in the case of a monomolecular film of oil in water, no stable surface ripples can be produced by pressure variation along the surface. The effect of surface wind is thus to produce a disturbance which passes through the film and is dissipated in the deeper water.

The effect of the oil thus causes an indirect increase in friction and this accounts for the damping effect on the waves.

Experimental Investigation of Wind Tunnel Interference on the Downwash Behind an Aerofoil. (A. Silverstein and S. Katzoff, N.A.C.A. Report No. 609, 1937.) (49/4 U.S.A.)

The interference of the wind-tunnel boundaries on the downwash behind an aerofoil has been experimentally investigated and the results have been compared with the available theoretical results for open-throat wind tunnels. As in previous studies, the simplified theoretical treatment that assumes the test section to be an infinite free jet has been shown to be satisfactory at the lifting line. The experimental results, however, show that this assumption may lead to erroneous conclusions regarding the corrections to be applied to the downwash in the region behind the aerofoil where the tail surfaces are normally located. The results of a theory based on the more accurate concept of the open-jet wind tunnel as a finite length of free jet provided with a closed exit passage are in good qualitative agreement with the experimental results.

The Suspension of Solids in a Turbulent Stream. (E. G. Richardson, Proc. Roy. Soc., Series A, Vol. 162, No. 911, 15/10/37, pp. 583-97.) (49/5 Great Britain.)

It is shown how the concept of an " austausch (or exchange) coefficient " in problems involving the diffusion of turbulence may be applied to the study of the distribution of solid material in a turbulent stream. A technique is developed by means of which the relative quantities of solid carried in suspension at different levels in a water channel having a bed of graded sand can be measured, and the results applied to predict how the " austausch " varies in the vicinity of the bed. The factor in question is found to increase in direct proportion to height at first, but rapidly reaches a constant value in the main stream. Measurements in a natural river also indicate an approximately constant value, and, making this assumption of constant " austausch," it is shown that a simple apparatus enables one to make observations of the total silt content of a river from time to time.

Note on the Interference Effect of the Walls of a Pipe upon the Moment of a Rayleigh Disc. (Proc. Phys. Math. Soc. (Japan), Vol. 19, No. 4, 1937, pp. 329-36. Phys. Berichte, Vol. 18, No. 18, 1937, p. 1631.) (49/6 Japan.)

In the case of two-dimensioned frictional flow round a plate inclined at an angle to the flow, a couple is produced tending to turn the plate at right angles to the flow. In a previous paper the author has shown that this moment is increased if the plate is situated in a finite channel with parallel walls. The theoretical conclusions are confirmed by experiment with a circular plate in a circular tube.

Air Resistance of Railroad Equipment. (A. I. Lipetz, Trans. A.S.M.E., Vol. 59, No. 7, Oct., 1937, pp. 617-40.) (49/7 U.S.A.)

After determining the air-resistance formulæ for the models used in the tests, the author expands the coefficients of the formulæ to apply to full-scale equipment, and further simplifies the formulæ for application to the prototypes of the models.

He compares air-resistance of full-scale equipment as obtained from the formulæ derived from test results and the simplified formulæ, presenting such data in tabular as well as graphical form. The author concludes his paper with a discussion of air-resistance tests of full-size equipment and savings in power affected by streamlining.

Mechanism of Disintegration of Liquid Jets. (P. H. Schweitzer, J. Applied Physics, Vol. 8, No. 8, August, 1937, pp. 513-521.) (49/8 U.S.A.)

The velocity distribution in the jet immediately after it has left the nozzle will be sensibly equal to that existing in the tube and may thus be of the laminar, semi-turbulent or completely turbulent type. In the latter case, the jet will almost immediately break up under the influence of the radial velocity components, even if injected into a vacuum. A laminar jet will maintain its shape over a considerable distance till it finally disintegrates under the combined action of air friction and surface tension. The semi-turbulent case occupies an intermediate position, depending on the thickness of the laminar protecting sheaths.

It thus appears that viscosity is the decisive factor in determining disintegration. The influence of nozzle designs is very great, long smooth walled orifices delaying disintegration considerably. On the other hand, rough projections at the nozzle or the imparting of a rotary motion to the jet at the exit reduces the stability. (17 references.)

The Measurement of Aerodynamic Qualities of Aircraft. (M. Precoul, L'Aeron., No. 211, Dec., 1936 (Suppt. L'Aerotechnique), pp. 145-154.) (49/9 France.)

Formulæ are deduced by means of which the aerodynamic qualities of aeroplanes can be calculated from given dimensions and performance figures. Formula are first obtained for fineness coefficient, minimum drag coefficient, maximum lift coefficient and maximum/minimum speed ratio for ground conditions and altitude corrections are then applied. Tables of comparative results are worked out for German, French, U.S.A., British, Dutch and Italian planes in the following six categories: Single engine transport planes >100 b.h.p., single engine transport planes <100 b.h.p., speed record planes, single engine scouts, and large and small transport planes.

The Influence of Design and Safety Appliances on the Stressing of Aircraft when Pulling Out of a Dive. (W. Kaul, L.F.F., Vol. 14, No. 4-5, 20/4/37, pp. 191-195.) (49/10 Germany.)

By simplifying the equation of longitudinal controlled motion, the author derives simple expressions for the wing and elevator loading, and determines the effect of such constructional features as span, surface loading, depth ratio of rudder, etc.

In order to reduce the stressing when pulling out of a dive and thus reduce constructional weight, the author proposes to limit the effect of the elevator to an extent compatible with other flying qualities, especially as regards perfect three-point landing with the foremost position of the C.G. The effect of the elevator can be limited by shortening (reduction of depth ratio) or the possible deflection can be controlled when diving.

The latter device can be rendered automatic by making the control a function of the dynamic head (see Abstract 49/11).

Aircraft Design and Improved Performance. (G. Bock, Luftwissen, Vol. 4, No. 4, April, 1937, pp. 104-115.) (49/11 Germany.)

The author considers in detail aerodynamic losses occurring at the propeller, the profile resistance of the wings and the drag of the fuselage and radiators.

The performance limits of aircraft of modern design are estimated and the possibilities of a saving in constructional weight are reviewed. In this connection

special reference is made to an improved form of spot welding with controlled welding current and electrode pressure.

In order to prevent ultra light structure being subjected to undue stresses during manœuvres, the D.V.L. working in conjunction with Messrs. Siemens have developed an automatic elevator control in which the maximum possible rudder deflection becomes automatically less as the dynamic head increases.

Problems Arising Out of the Vibration of Aircraft. (G. A. A. Fiore, L'Aerotecnica, Vol. 17, No. 3, March, 1937, pp. 187-216.) (49/12 Italy.)

The author deals with various types of self-excited motion. It appears that the critical speed of wing flutter is considerably diminished at large angles of incidence (stall). The autorotation produced by unbalanced ailerons is discussed as well as reversal of aileron control due to wing twist.

Experimental wing tests are described, the wing being vibrated by rotating unbalanced weights or springs and eccentrics.

In conclusion the benefit arising from flexible engine mounts is pointed out.

Calculation of Velocity Reached in a Nose Dive. (Report of the Italian Air Ministry, L'Aerotecnica, Vol. 17, No. 3, March, 1937, pp. 217-223.) (49/13 Italy.)

The velocity increase during a power dive is calculated by means of auxiliary charts. Variation of air density is taken into account and the thrust, angle of incidence and path angle are kept constant in steps of 6,000 feet.

The same subject is treated somewhat differently in N.A.C.A. Tech. Note No. 599. (Abstract A, No. 47, item 15.)

Wind Tunnel Experiments on Combined Torsional and Bending Vibrations of Aircraft Wings. (H. Voigt, L.F.F., Vol. 14, No. 9, 20/9/37, pp. 427-33.) (49/14 Germany.)

In order to test the theory of wing oscillations with degrees of freedom in flexure and torsion, a wing was suspended in a wind tunnel between two walls in such a way that it could perform both vertical oscillations (flexural) and torsional oscillations about any transverse axis. All elasticity and mass parameters could be varied. The negligibly small natural damping of the system could be artifically increased. An enlarged photographic record of the oscillations was obtained by the use of concave mirrors. The critical velocities determined experimentally agree with those calculated from the theories of Wagner and Küssner within the range of experimental and computational accuracy. An extremely narrow wing tested without lateral walls (three-dimensional problem) showed the same oscillations as with walls (two-dimensional problem).

Researches on the Safety of Aircraft with Special Reference to Vibration Phenomena. (K. H. Ruehl, Lilienthal Society Yearbook, 1936, pp. 258-264.) (49/15 Germany.)

The author calculates the critical velocity (flutter) of a given wing by three independent methods and obtains results varying by more than 3 to 1.

In the case of a plane (two-dimensional) wing, however, all three methods were in satisfactory agreement.

This points to the urgent need of further experiments with three-dimensional models.

In the second part of the paper the author gives a critical review of the safety factors laid down in the strength specification covering those parts of an aircraft which are subject to lifting forces. It is specially emphasised that in many cases the loading is periodic and the possibility of fatigue must be kept in view.

Motion of the Two-Control Aeroplane in Rectilinear Flight after Initial Disturbances with Introduction of Controls Following an Exponential Law. (A. Klemin, N.A.C.A. Tech. Note No. 615, Sept., 1937.) (49/16 U.S.A.)

An aeroplane in steady rectilinear flight was assumed to experience an initial disturbance in rolling or yawing velocity. The equations of motion were solved to see if it were possible to hasten recovery of a stable aeroplane or to secure recovery of an unstable aeroplane by the application of a single lateral control following an exponential law.

The sample computations indicate that, for initial disturbances complex in character, it would be difficult to secure correlation with one type of exponential control. The possibility is visualised that two-control operation may seriously impair the ability to hasten recovery or counteract instability.

Characteristics of Six Propellers including the High Speed Range. (T. Theodorsen, G. W. Stickle and M. J. Brevoort, N.A.C.A. Report No. 594, 1937.) (49/17 U.S.A.)

This investigation is part of an extensive experimental study that has been carried out at full-scale in the N.A.C.A. 20-foot tunnel, the purpose of which has been to furnish information in regard to the functioning of the propeller-cowling-nacelle unit under all conditions of take-off, climbing, and normal flight.

The results show very striking differences in the aerodynamic qualities of the various propellers, particularly in the high speed range. Also of interest is the fact that the conventional propeller is shown to reach its peak efficiency in a range of 200 to 350 miles per hour and at a blade angle of approximately 35°. The inadequacy of using the propulsive efficiency unconditionally as a figure of merit is shown.

The adoption of some standard nacelle unit is therefore recommended as a basis for the comparative testing of propellers.

Two New Longitudinal Stability Constants. (A. Klemin and J. G. Beerer, J. Aeron. Sci., Vol. 4, No. 11, Sept., 1937, pp. 453-9.) (49/18 U.S.A.)

The way to define longitudinal stability quantitatively is with reference to time; duration of the period, duration of the time to damp to half amplitude, and ratio of time to damp to the period.

If it is conceded that longitudinal stability should be defined in terms of periods of oscillation and times to damp to half amplitude, then the simple use of Diehl's coefficient of static stability is not adequate, and the designer should make at least some attempt to go a little deeper into the subject.

Consideration should be given to the effects of linear dimensions, wing loading, and air density, and the practical approach in design would be to start with an aeroplane whose longitudinal stability characteristics are known, and known to be satisfactory, and to make allowance for variations in the above parameters when passing to a new design.

Wing Loading. (W. C. Nelson, J. Aeron. Sci., Vol. 4, No. 11, Sept., 1937, pp. 469-72.) (49/19 U.S.A.)

A study is made here of the proper correlation between wing loading and high altitude cruising efficiency as applied to the commercial transport field. A wide range of the major performance parameters of span loading, power loading, and drag loading is taken to make the analysis as general as possible. From a study of the charts developed it is obvious that there is a definite, desirable value of the wing loading for any specific altitude cruising condition. Cruising at a 65 per cent. power factor and with a power loading of 10lb. per b.h.p. or more, the optimum wing loading is 25lb. per sq. ft. or less at 35,000ft. altitude, and 20lb. per sq. ft. or less at 50,000ft. altitude for a conventional transport design.

Flight Test Research on a Small Bi-Motor Aeroplane. (C. L. Johnson, J. Aeron. Sci., Vol. 4, No. 11, Sept., 1937, pp. 473-7.) (49/20 U.S.A.)

The aeroplane Lockheed Model 12 bi-motor is a small, high performance ship with a gross weight of 8,400lb. and a top speed close to 230 m.p.h. The programme of testing included among other things, the determination of:—

(1) Lift and drag characteristics of the aeroplane.
(2) Effect of power on maximum lift coefficient with and without wing flaps extended.
(3) The drag of the streamlined tail wheel and strut.
(4) The effect of several servo-tab ratios in reducing the control forces.
(5) A one point measurement of the flow speed ratio over the wing flap with power on and off.
(6) Aeroplane altimeter error due to position of pitot static head.
(7) Factors affecting accuracy of engine fuel consumption tests.

The Economics of Speed. (T. P. Wright, J. Aeron. Sci., Vol. 4, No. 11, Sept., 1937, p. 478.) (Copy of complete lecture available in R.T.P.) (49/21 U.S.A.)

Great progress has been made in refining the aeroplane in the past eight years. In 1928 sixty-six per cent. of the total horse-power was wasted in overcoming unnecessary drag. This waste is now only twenty-five per cent. And whereas their speeds were but sixty-five per cent. as fast as they should have been, present-day speeds are eighty-nine per cent. as fast, very little waste in drag remaining.

As direct proof of the various factors cited, reference is made to the growth of air transport throughout the past seven years wherein during a major business depression, a constant rate of increase in passenger miles travelled of thirty per cent. each year over the previous year has maintained. It is concluded definitely that speed is sound economically.

In order to gain an additional mile per hour in cruising speed, it is worth while spending three thousand dollars on the design and construction and one thousand dollars in the building of the production article.

Pressure Distribution on a Wing Section with Slotted Flap in Free Flight. (G. Kiel, L.F.F., Vol. 14, No. 2, 20/2/37, pp. 71-84. Translation in N.A.C.A. Tech. Memo. No. 835.) (49/22 Germany.)

Pressure distribution curves were obtained in unaccelerated flight on a wing section with slotted flap at flap deflections of 0°, 19°, 32°. The flap chord was 0.296 times the over-all wing chord. With a flap deflection of 19° the pressure distribution curves show a somewhat fuller form (that is, less peaked) than is the case with flap neutral. With the flap deflected 19° there is only a relatively slight change both in the maximum pressure at the flap leading edge as well as in the general pressure distribution over the flap. Evidently the main wing diverts the flow in such a manner that the air flow direction at the flap experiences only a slight change. With a flap deflection of 32° a marked pressure rise occurs at the leading edge of the flap, considerably exceeding that at the wing leading edge at small normal force coefficients. As the normal force coefficient increases a rather steep pressure peak is built up at the nose of the wing while at the flap leading edge the pressure increases at a considerably lower rate.

The Measurement of Airspeed of Aeroplanes. (F. L. Thompson, N.A.C.A. Tech. Note, No. 616, October, 1937.) (49/23 U.S.A.)

Various methods of measuring the air speed of aeroplanes are described. Particular emphasis is placed on the procedure required to obtain precise measurements of speed by the use of the suspended pitot static head or the suspended

static head. Typical calibration curves for service installations of pitot static heads are shown and the relation between errors in air speed and corresponding errors in observed altitude for such installations is discussed. There is included a brief discussion of various speed course methods of measuring speed.

Cinematograph Study of the Stability and Manœuvrability of Aircraft. (C. Brachet, La Science et la Vie, No. 243, Sept., 1937, pp. 181-8.) (49/24 France.)

The stability and manœuvrability can only be studied satisfactorily by experiments in flight. At the French centre of Villacoublay some information on this subject is obtained in a simple manner, the pilot recording the effort and displacement of the control stick by reading a spring balance and scale. This, however, necessitates steady flight conditions. Professor Haus, of Gand University (Belgium) has perfected a photographic scheme which enables the readings of various instruments which define the conditions of the aircraft at any instant to be recorded.

The following 11 factors are registered simultaneously by the suitable grouping of 17 instrument dials:—

(1) Altitude of flight.
(2) R.p.m. of engine.
(3) Speed of aircraft along its trajectory.
(4) Angle of incidence of the wing.
(5) The slope of the trajectory with regard to the horizon.
(6) The angular velocity of the aircraft.
(7) The value of apparent gravity.
(8) The position of the principal control surfaces (elevator, rudder, ailerons).
(9) The corresponding forces required to hold the control surfaces in the position indicated.
(10) The inclination of the aircraft with regard to the horizon.
(11) The time.

The author recalls that such " flying laboratories " were suggested over 15 years ago by the French scientist Magnan and is of the opinion that France is still leading in this type of stability research.

Control Surface and Wing Stability Problems. (A. G. Pugsley, J.R. Aeron. Soc., Vol. 41, No. 323, Nov., 1937, pp. 975-96.) (49/25 Great Britain.)

This paper seeks to draw from current research work on flutter and related problems results of general design significance; and, avoiding mathematics, endeavours to set these results out in relation to past and present problems.

A preliminary section of the paper indicates the main stability and allied troubles concerned and draws attention to the general similarity between wings and tailplanes in relation to these troubles. The remainder of the paper is then devoted to a discussion of the problems involved in terms of wings and ailerons.

For this purpose a " stiffness diagram " is constructed for a typical wing, indicating the relative stiffnesses, etc., required to prevent wing aileron flutter, aileron reversal, and wing divergence. By means of this diagram the course of recent history in relation to wing aileron flutter and aileron reversal is illustrated, and attention is then given to present and future tendencies and problems. The current tendency to employ wings of high density—arising largely from high wing loadings—is making wing flutter the problem of immediate importance, and ways of avoiding the provision of increased stiffness as usually adopted to prevent this trouble, as well as to prevent aileron reversal and wing divergence, are discussed.

Appendices are given commenting on the variation of wing flutter speed with altitude and on the modern tendency to use wings of low flexural stiffness.

Incendiary Media. (C. W. van Hoogstraten, Chem. Weekblad, Vol. 34, pp. 56-9, 1937. Chem. Absts., Vol. 31, No. 19, 10/10/37, p. 7251.) (49/26 Holland.)

Incendiary bomb fillings and methods of combating the resultant fires are discussed with particular reference to P. Thermit mixtures, and electron (Al-Mg alloy) bombs.

Although intensely hot, the actual burning time of these chemical fillings is short so that bombs of at least 25 kg. weight are required, unless the target is exceptionally inflammable.

In the early stages, whilst the original filling is still burning, it is practically impossible to put out the fire. The final conflagration can however be fought by normal means. In certain cases fire-fighting bombs containing mixture of bicarbonate of soda and sand can be used, the filling being spread by a mild explosive.

The Relative Advantages of Chemical and Mechanical Time Fuses for Projectiles. (C. Weninger, W. T. M., Vol. 41, No. 1, Jan., 1937, pp. 14-18.) (49/27 Germany.)

The author is of the opinion that during the next few years the chemical fuse will retain the field for short and medium distances on the ground, but that for long distance work and especially anti-aircraft fire the mechanical time fuse will become fairly general.

By properly organised mass production the extra cost of the mechanical type is not very great and in any case cost should not be a deciding feature, but reliability and the confidence given to the troops by the knowledge that their technical equipment is the best possible.

The design of mechanical time fuses calls for the proper combination of two factors: great sensitivity and yet safety in handling. As far as operation goes, we can broadly differentiate between those fuses which are operated by springs and those which depend on the spin of the shell only. In anti-aircraft work, the setting of the fuse must occupy the least possible time and this rules out designs where the spring has to be wound through several turns. In a recent development the mechanical time fuse is " set " electrically when the shell leaves the gun (capacity effect). The use of electricity opens up interesting possibilities, such as utilising the variation of the potential gradient of the atmosphere to fire the shell at a predetermined altitude.

Considering, however, that it took 15 years to develop the mechanical time fuse to its present state, the author is of the opinion that a considerable further period must elapse before the electrical time fuse will be ready for general issue.

Gas Masks—Military and Civilian Pattern. (W. Mielenz, Z.V.D.I., Vol. 81, No. 44, 30/10/37, pp. 1273-9.) (49/28 Germany.)

The gas masks employed by various governments are described and illustrated. It is claimed that in many countries the civilian mask gives insufficient protection. To produce an efficient article at a small price requires a considerable amount of experience.

Metallurgy and the Aero Engine. (D. R. Pye, The Engineer, No. 4261, 10/9/37, p. 292-4.) (49/29 Great Britain.)

The remarkable increase of recent years in the power of aero engines has been largely due to improvements in the quality of the fuel available, but it could not have been achieved without many parallel improvements of a metallurgical character. The increase of power has involved thermal and mechanical problems, and of the former, those associated with the piston and exhaust valve are the most formidable. On the mechanical side, the problem is that of maintaining two surfaces at high temperatures rubbing without seizure. It is of importance to

consider what treatment of the metal surfaces themselves will render them less liable to seizure when the lubricant can no longer provide sufficient protection. Metal surfaces, normally crystalline in their atomic structure, can in some circumstances be rendered amorphous, and there are reasons for thinking that in this state they form more satisfactory bearing surfaces. A study of the ultimate structure of metal surfaces, such as is provided by the physicist, may be expected to afford valuable assistance in the engineer's problem of bearing surfaces.

Vibration Isolating Radial Engine Mounts. (W. E. Stitz, A.C.I.C., Vol. 8, No. 707, 1/2/37, pp. 1-25.) (49/30 U.S.A.)

This report presents the vibrating forces originating in a radial engine with propeller and a method for isolating these forces from the aeroplane structure. The nature, value, line of action, and frequency of the vibrating forces indicate that for complete isolation a mounting having 6° of freedom is necessary. With this in mind, a type of mount has been developed having 6° of freedom, with the six natural frequencies located very close together and set in the idling range of engine revolutions per minute.

Also, a method is given for calculating the required spring rates of the rubber bushings used and the six natural frequencies of the mounting.

Full-Scale Tests of N.A.C.A. Cowlings. (T. Theodorsen, M. J. Brevoort and G. W. Stickle, N.A.C.A. Report No. 592, 1937.) (49/31 U.S.A.)

A comprehensive investigation has been carried on with full-scale models in the N.A.C.A. 20-foot wind tunnel, the general purpose of which is to furnish information in regard to the physical functioning of the composite propeller-nacelle unit under all conditions of take-off, taxying, and normal flight. This report deals exclusively with the cowling characteristics under conditions of normal flight.

The optimum shape of a low drag cowling has been determined. The shape of the leading edge and the contours of the exit passage are the cause of large losses when improperly designed. The importance of providing means for regulating the quantity of cooling air to the minimum that will prevent excessive losses at high speeds has been demonstrated. The superiority of a baffled over an unbaffled engine has been verified and it has, furthermore, been shown that tightly fitting baffles are superior to the deflector type.

Cooling of a Radial Engine in Flight. (O. W. Schey and B. Pinkel, J. Aeron. Sci., Vol. 4, No. 11, Sept., 1937, pp. 448-52.) (49/32 U.S.A.)

A study of the heat transfer processes of air-cooled engine cylinders has been made at the laboratories of the National Advisory Committee for Aeronautics on single-cylinder blower-cooled test engines. Because of the difference in airflow conditions between a blower-cooled engine and a cowled engine in flight, it was considered advisable to make flight tests to correlate with the laboratory tests. The present paper gives the results of flight tests to determine the effect of indicated horse-power and mass flow of cooling air on cylinder temperatures and shows the correlation between these results and the results of the laboratory tests.

The main difficulty attending the study of engine cooling in flight is the independent control and measurement of the many engine and cooling variables so that their separate effects may be studied. In the present tests an attempt was made to obtain complete control of the test conditions. A novel feature of the tests was the method used for independently varying the velocity of the cooling air and the cylinder horse-power of the engine.

Some Effects of Ignition Timing and Rate of Burning on the Thermodynamic Performances of High Speed Compression Ignition Engines. (S. Awano, Aer. Res. Inst., Tokio, Report No. 155, Sept., 1937.) (49/33 Japan.)

A successive graphical method of estimating the cylinder pressure or the mean gas temperature for any given combustion time rate and ignition timing is presented as an application of the entropy charts of combustion gases. With this method, some general effects of important factors, such as the rate of combustion, ignition timing, and extent of combustion, on the performance of the cycle realised in high speed compression ignition engines are examined theoretically.

The results of these theoretical calculations, which show good agreement with many experiments, are sufficient to illustrate the phenomena in practice.

The N.A.C.A. Nose Slot Cowl. (Inter. Avia., No. 483, 23/10/37, pp. 1-3.) (49/34 U.S.A.)

In the case of this cowling, the exit opening of the cooling air is not, as usual, located behind the engine but at the nose of the cowl. The air enters the cowling conventionally in the central front, is guided by baffles between the cylinder and is then returned to the nose ring via the cylinder head and is discharged through a slot.

It appears that this design is specially effective at low flying speed. The pressure distribution on the cowl (on which the cooling depends) is, however, very sensitive to change in speed and propeller slipstream and it appears difficult to obtain a single design which will be superior to the orthodox cowl over large ranges of operating conditions.

Trend of Air-Cooled Aero Engines—The Next Five Years. (A. H. R. Fedden, J.S.A.E., Vol. 41, No. 4, Oct., 1937, pp. 437-454, 467.) (49/35 Great Britain.)

The author suggests the following main aircraft categories:—

Type.	Maximum Speed (m.p.h.)	Cruising Speed (m.p.h.)	Cruising Range (miles).
Civil—			
Land	275	220	1,000-1,500
Sea	250	200	1,500-2,000
Special long range ...	250	220	3,000-4,000
Military—			
Destroyers	425/450	—	1½-2 hours
Multiplace Fighters ...	400	—	1½-2 hours
Medium Bombers ...	—	300	6 ,,
Heavy Bombers ...	—	275	8 ,,
Seaplanes	270	220	10 ,,

These categories, with the exception of the smaller civil types can be covered by the following four sizes in aircraft engines:—

Horse-Power.	Weight with Standard Equipment.
750	820lb.
1,150	1,250lb.
1,550	1,550lb.
2,000	2,100lb.

In the opinion of the author, the above sizes can all be covered satisfactorily by air-cooled radial designs (twin row in the larger sizes). Installation difficulties will decrease with size of aircraft (thickness of wing).

The Torsional Critical Speed of Geared Aeroplane Engines. (J. P. Den. Hartog and J. P. Butterfield, J. Aer. Sci., Vol. 4, No. 12, Oct., 1937, pp. 487-90.) (49/36 U.S.A.)

An analysis of the effect of gears on the torsional critical speed of an engine is made and the percentage deviation caused by this effect is illustrated. For stiff engine mounts the shaft critical speed is lowered, while for very flexible mounts that critical is raised by the action of the gears. These deviations may be as much as 15 per cent. either way.

Determining the Oiliness of Mineral Oils. (T. Zhuze, Azerbaidzhanskoe Neftyanoe Khoz, 1937, No. 1, pp. 68-77. Chem. Absts., Vol. 31, No. 19, 10/10/37, p. 7235.) (49/37 Poland.)

The heats of wetting were investigated with a Russian clay ("askanit") which served as a criteria for the determination of the adhesion properties of various refined oils. The adhesion properties of Baku lubricating oils fluctuate within a narrow range, increasing slightly with higher molecular weight. Small amounts of resin improve the wetting properties of oils. Paraffin-base oils have a lowered wetting ability. Oils made by selective solvent process are inferior in wetting ability to acid-treated oils. Oils with a high temperature viscosity index have low adhesion properties. The latter can be improved by adding small amounts of cyclohexanol. (Thirty-one references.)

Collected Results on Viscosity of Lubricants Under Pressure. Part I—Fatty Oils. (M. D. Hersey and R. F. Hopkins, J. Applied Physics, Vol. 8, No. 8, August, 1937, pp. 560-6.) (49/38 U.S.A.)

The paper gives a review of results obtained at various laboratories. The principal oils tested were: Castor, lard, rapeseed, sperm, linseed, peanut and whale. The temperature ranged from about 1°C. to 100°C. and the pressure from 600 to 9,000 atmospheres, although these ranges were not used for all the oils. The most complete results are available for castor oil for which the viscosity at 100°C. increase about ten-fold for a pressure increase of 2,800 atmospheres.

Several of the fatty oils show apparent solidification at high pressures and low temperatures and similar phenomena have been reported for certain compounded oils as well as petroleum oils containing a sufficient quantity of wax. (Nine references.)

Instruments for Measuring Rate of Climb and Fall. (H. Danielzig, Luftwissen, Vol. 4, No. 5, May, 1937, pp. 153-8.) (49/39 Germany.)

The ordinary variometer is very sluggish in its readings and is therefore unsuitable whenever co-ordination of rate of climb or fall with other instrument readings is required on a time basis.

On the other hand, the normal barograph, even if free from lag and friction, does not provide a sufficiently open scale to render differentiation possible. This is especially the case if the experiments for reasons of safety have to be carried out at a reasonable altitude.

The D.V.L. have overcome the objection by employing a differential type of barograph which records photographically both the static pressure and the difference in static pressure between the air surrounding the aircraft and the air in a four-litre capacity. By making the diaphragm of the differential instrument sufficiently weak, a very open scale for the rate of climb can be obtained at any altitude. The instrument is calibrated on the ground and provided the tests are carried out at altitudes below 1,000 m., the errors due to change in pressure of the capacity with height are less than 1 per cent.

A Simple Method of Measuring Rotational Speeds. (L. B. Snoddy and J. W. Beams, Science (U.S.A.), Vol. 85, 1937, pp. 273-4. Phys. Berichte, Vol. 18, No. 18, 1937, p. 1625.) (49/40 U.S.A.)

A permanent magnet attached to the rotating shaft generates an alternating current the frequency of which depends on the r.p.m. The resultant current is applied to a tuned bridge circuit and the induction or capacity in one arm of the bridge is altered till the indicating instrument shows that a balance has been obtained. The required r.p.s. N follows from the equation $N=\frac{1}{2}\pi\sqrt{(LC)}$ when L and C are the induction and capacity respectively in the bridge circuit. The measuring circuit will deal with a speed range from 500 to 3,000 revolutions per second.

A Mechanical Counter of Improved Resolving Power for Electrical Impulses. (J. L. Tuck, J. Sci. Inst., Vol. 13, No. 11, Nov., 1936, pp. 366-7.) (49/41 Great Britain.)

The counter essentially consists of the vibrating reed of a loudspeaker which actuates the escapement of a 1/100 sec. stop watch from which the balance wheel has been removed. The reed operates a contact breaker incorporated in a thyratron circuit and the frequency of the system can be adjusted to cover the range of 50-180 impulses per second.

The D.V.L. Neon Light Engine Indicator. (M. Schenermeyer, Archiv fur Technische Messen, No. 73, July, 1937, pp. T. 89-90.) (49/42 Germany.)

The indicator works on the pressure balance system and is in some respects similar to the R.A.E. Farnborough indicator. Instead of the floating disc valve of the latter, a pressure membrane is used, the motion of which causes a special neon point source to light up. This source is sufficiently powerful to give a photographic record in a rotating drum, the indicator diagram thus having the appearance of dark silhouettes on a white background.

The article gives examples of the types of records obtained and also describes an application of the principle to measuring the injection time in the case of Diesel engines.

Discharge Coefficient of Standard Nozzles and Pressure Drop in Pipes Under Conditions of Pulsating Flow. (E. Estel, Phys. Zeit., Vol. 38, No. 19, 1/10/37, pp. 748-58.) (49/43 Germany.)

The experiments were carried out with water, the pulsation being produced by an oscillating sector in the pipe line. In the case of nozzles and rough tubes (the roughness being produced either by sand grains or throttle plates) the effect of moderate pulsations (of the order of 15 per cent. on the velocity) on the discharge and resistance coefficients were slight compared with the values obtained under steady flow conditions.

In the case of smooth tubes, however, the resistance coefficient showed a marked variation with amplitude and frequency of the oscillations.

Stresses in Ring Frames Fitted for the Introduction of Longitudinal Forces in Cylindrical and Conical Shells. (K. Drescher and H. Gropler, L.F.F., Vol. 14, No. 2, 20/2/37, pp. 63-71.) (49/44 Germany.)

The bending moment at the frames is given in non-dimensional form in a series of diagrams for cylindrical and conical shells of circular and elliptic cross-sections. Both symmetrical and asymmetrical condition of loading are considered. In the case of the former, the frame moment for a circular section is expressed as

$$m_a = mPa_1^2/h$$

where m = a coefficient.

P = longitudinal force introduced.

a_1 = radius of circle.

h = distance between end frames in cm.

The coefficient m is plotted for various values of x/a_1 as a function of v/u, where x/a_1 and v/u determine respectively the point of application of force and the point where the bending moment is required.

Similar curves are plotted for the asymmetrical case. By the use of these charts a general idea of the ring stresses can be obtained without involved calculations.

A Machine and Method of Rolling Sheet Metal to Compound Curvature. (A. Klemin, Aero Digest, Vol. 31, No. 4, Oct., 1937, pp. 46-8 and 100-1.) (49/45 U.S.A.)

Since the sheets are preformed by controlled pressure and regular rolling process, the original strength of the material is more likely to be maintained than in processes where violent impact is employed.

If single, or at least a small number of, sheets are substituted for a large number of sheets, riveted or otherwise fastened together, there is likelihood of gain in strength and weight, with the avoidance of multiple connection.

The system should be useful for every part of the aeroplane fuselage, wings, etc., and should have particular appeal in the construction of floats or hulls, where a single sheet is much more likely to be leak-proof than a number of sheets, however well riveted together or carefully caulked they may be.

With high speed ships, a reduction in the number of rivet heads, and the increase in smoothness resulting from the use of single sheets will serve indirectly to improve performance.

Directions for the Study of Hard Composite Dielectrics (Mouldings, Sheet and the Like). (J. Inst. Elec. Engs., Vol. 41, No. 490, 21/10/37, pp. 553-64.) (49/46 Great Britain.)

As a result of experience gained it has been found desirable to modify several of the tests hitherto applied to hard composite dielectrics (mouldings and the like) and to introduce a series of "temperature grades" which, although purely arbitrary, are closely related to the different classes of composites in general use.

The tests described are not intended as acceptance tests in the purchase of such materials, but it is anticipated that the British Standards Institution will issue a series of purchasing specifications, based largely upon these recommendations, which will define appropriate limits to the specified electrical and mechanical properties for the class of materials covered by this report.

The Behaviour of Unprotected and Protected Wood in Fires. (O. Graf and F. Kaufmann, Feuerschutz, Vol. 17, 1937, p. 137. Chem. Absts., Vol. 31, No. 20, 20/10/37, p. 7650.) (49/47 Germany.)

Samples of wood fireproofed with salt solutions, water glass mixtures, oil and lacquer mixtures, chlorinated rubber paints, and organic foam formers were subjected to fire tests. Protective coatings cannot prevent the decomposition of wood when it has reached its decomposition temperature. The protective effect of these coatings is poorer on objects of large diameter than of small diameter. Fireproofing hardly extends the carrying power of weighted wooden beams. After one year's storage the protective action of fireproofing agents decreased 25 per cent.

Stability of Structural Members Under Axial Load. (E. E. Lundquist, N.A.C.A. Tech. Note No. 617, October, 1937.) (49/48 U.S.A.)

The principles of the cross method of moment distribution are used to check the stability of structural members under axial load. A brief theoretical treatment of the subject, together with an illustrative problem, is included as well as a discussion of the reduced modulus at high stresses and a set of tables to aid in the solution of practical problems.

The Relation Between Damping Capacity and Other Physical Properties. (G. R. Brophy and A. E. Parker, Trans. American Soc., Metals, Vol. 24, 1936, pp. 919-31. Phys. Berichte, Vol. 18, No. 18, 1937, p. 1636.) (49/49 U.S.A.)

The damping capacity of various steels is examined in relation to the load, the chemical composition, the heat treatment and subsequent working and the temperature of utilisation. The damping will depend on the load imposed by vibration as well as on the steady load. It appears that the damping capacity affects the resultant fatigue stresses and the authors state that the extent of creep at high temperature can be predicted if the damping at the same temperature is known.

This, however, is only possible if the steel undergoes no structural changes apart from size of grain.

The Use of Rubber in Aircraft Construction. (G. Genin, La Science et la Vie, No. 243, Sept., 1937, pp. 178-180.) (49/50 France.)

The main use of rubber on aircraft is in connection with landing wheel tyres.

Modern aircraft tyres for heavy machines are almost exclusively of the low pressure type (inflation pressure between 1 and 2 kg./cm.^{2}).

The tyres are mounted directly on the hub and the resulting small overall diameter of the wheel (of the order of 20in. for a load of nearly one ton) greatly facilitates the operation of the retractable landing gear. On the other hand, the small hub calls for very special wheel brake designs.

Other uses of rubber on aircraft are the following:—

(1) Engine mounting.
(2) Support for pipe lines.
(3) Shock absorber for the undercarriage (working either in compression or extension).
(4) Anti-ice devices, such as the Goodrich.

Abstract of Progress Report No. 3 on Heavy Helical Springs. (C. T. Edgerton, Trans. A.S.M.E., Vol. 59, No. 7, October, 1937, pp. 609-16.) (49/51 U.S.A.)

This abstract gives the principal results of static tension and torsion tests, rotating beam endurance testing in bending, and torsion endurance tests of straight pieces of plain carbon basis open hearth, plain carbon electric furnace and silicon-vanadium spring steel. These results are compared with those for other steels.

Increasing the Strength of Aluminium Alloy Columns by Pre-Stressing. (M. Holt and E. C. Hartmann, N.A.C.A. Technical Note No. 618, October, 1937.) (49/52 U.S.A.)

A series of tests was made in which the column strength of 17 S-T tubing was increased as much as 50 per cent. by prestressing the tubing to 40,000 pounds per square inch in compression under conditions of support that prevented column failure at this stress. This prestressing achieves its beneficial effects entirely by improving the compressive properties of the material, principally the proportional limit.

Variation of the Modulus of Elasticity of Duralumin. (W. L. Howland, J. Aer. Sci., Vol. 4, No. 12, Oct., 1937, pp. 507-9.) (49/53 U.S.A.)

This paper gives curves for the variation of E_σ for four light alloys (17 ST, 17 SRT, 24 ST, and 24 SRT), plotted against stress. These curves are important in that they show that the average value of E_σ has no sudden changes, so that at no particular stress can one be sure of an inelastic failure of a member. Defined yield point is an interesting method of comparing two metals, but it is of no value or help in solving many of the problems of the research student or the

stress analyst. If the stress analyst uses the defined yield point in calculations, he should use the correct values of E_s taken from the curves, whenever inelastic failures are involved.

Increase of Wind Velocity with Height. (J. Gilbert, Comp. Rend., Vol. 205, No. 6, 9/8/37, pp. 371-3.) (49/54 France.)

According to theory, the average wind velocity v near the ground increases logarithmically with the height z,

$$i.e.\ ,\ v = a + b \log z \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The weight of hoar frost dP on an element dz of a vertical rod varies directly as v,

$$i.e.,\ dP = Kvdz \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Eliminating v between (1) and (2) leads to a distribution of hoar frost with height which has been verified experimentally.

Concerning the Ice Accretion on Ailerons. (Inter. Avia., No. 487-8, 6/11/37, pp. 1-4.) (49/55 U.S.A.)

A report issued by the Goodrich Company (U.S.A.) deals with the development of the " over-shoe " de-icer from 1931 to date. Of great interest are the remarks on the accretion of ice on ailerons. It appears that this accretion is determined by the width and shape of the slot and on the area of aileron leading edge which projects below the lower surface of the wing at the aileron slot cut out. Ailerons of the constant slot width type ($\frac{1}{2}$in.) have given best results, and a strip attached to the trailing edges of the wing on the lower side to act as a closure for the aileron cut-out has led to a considerable reduction of ice formation on the leading edge of the aileron.

It is interesting to note that the appearance of small holes in the inflation elements of the wing de-icers (leading edge) has been traced to electro static effects which can be overcome by a conducting layer of graphite. The report concludes by stating that ice forming conditions are infinite variable. Not only does the ice differ in its adhesive qualities, but also the texture and shape and the formation are seldom alike.

Optical Specification of Light-Scattering Materials. (D. B. Judd, Bur. Stan. J. Res., Vol. 19, No. 3, Sept., 1937, pp. 287-317.) (49/56 U.S.A.)

In 1931 Kubelka and Munk worked out the relationship between reflectance and thickness of material for thin, homogeneous layers illuminated diffusely. In the equation expressing this relationship, the hypothetical ideal material is defined by two constants, reflectivity and coefficient of scatter. In the present paper are given data demonstrating how well several materials of commerce can be specified by these constants. These include data on vitreous enamel, dental silicate cement, cold-water paint, and paper.

Industrial Heater. (Aero Digest, Vol. 31, No. 4, Oct., 1937, p. 62.) (49/57 U.S.A.)

Heat source is a cast aluminium grid, which has been poured around a calrod heating element, thus eliminating hot wires and dead air space.

A motor driven, four-bladed aluminium fan, running on a graphite impregnated bronze bushing for quiet operation, dissipates heat from the entire surface of the circular grid and circulates the warm air. Heat can be directed wherever it is needed by moving adjustable deflectors mounted on the front of the unit.

Transmission of Radiant Energy Through the Atmosphere. (H. V. Hayes, Rev. Sci. Inst., Vol. 8, No. 9, Sept., 1937, pp. 342-345.) (49/58 U.S.A.)

Daily measurements were carried out over a period of six months over distances of 480 m. and 2,400 m. respectively with the Hayes radiometer as receiver, which is sensitive to all wave lengths from the ultra violet down to 15 micron.

The radiometer readings were amplified by means of a valve circuit and read on a milliameter, a clearly defined signal being defined as a deflection of $\frac{1}{2}$ m. amp. or more.

Two sources of radiant energy were employed. One consisted of a spiral of nichrom wire (1/200in. diameter) absorbing 25 w. The other consisted of a carbon arc, the current going up to $22\frac{1}{2}$ amp., with a maximum output of 650 w.

The sources of energy were placed at the focus of an 18in. parabolic reflector possessing a coating of rhodium. A similar reflector was used at the receiver end.

With a 25 w. source good signals could be obtained throughout over the shorter distance, and only on two days (snowing) did this source fail to give signals over the longer distance. With a more powerful source (650 w.), communication could be maintained over the longer distance of 2,400 m. under all weather conditions met with during the period.

Sound Field Due to a Vibrating Piston. (L. Gutin, Techn. Phys. U.S.S.R., Vol. 4, No. 5, 1937, pp. 404-413. Sci. Absts. A., Vol. 40, No. 478, 25/10/37, p. 1075.) (49/59 U.S.S.R.)

The sound field due to a piston oscillating in an infinite baffle is calculated and the directional characteristics determined. By combining the result with that applicable to a pair of pistons vibrating in opposite phases, the sound field due to a piston which radiates from one face only is calculable. This result is then used to study the acoustical characteristics of an exponential horn. Good agreement with experiment is obtained for the radiation factor of an exponential horn. The amplification factor of a horn used to collect sound is calculated, the special case in which the end of the horn is closed with a membrane being also considered.

Experimental Investigation of Effects of Equipment Size on Convection Heat Transfer and Flow Resistance in Cross Flow of Gases over Tube Banks. (E. C. Huge, Trans. A.S.M.E., Vol. 59, No. 7, October, 1937, pp. 573-8.) (49/60 U.S.A.)

Values of both gas-boundary conductance and friction factor for a given tube arrangement are consistent for all tube sizes from the full-scale two-inch tubes down to the Pierson model tubes of 0.31 inch, including the intermediate sizes of $\frac{1}{2}$ inch and $\frac{11}{16}$ inch tubes. This confirms the validity of the principle of similarity applied to tube banks (in spite of some departure from true geometric similarity in the ratio of length to diameter or to inter-tube space) for the range of Reynolds numbers tested, 2,000 to 70,000.

Report About the Electrical Investigations in Respect of the Hindenburg Catastrophe. (M. Dieckmann, German Research Congress, Munich, Inter. Avia., No. 482, 19/10/37, pp. 4-5.) (49/61 Germany.)

The catastrophe is attributed to the coincidence of the following five causes:—

1. Presence of explosive mixture, due to leak and faulty ventilation.
2. The external cover of the ship was wet.
3. A landing was made from a great height, *i.e.*, high electrical potential gradient.
4. The landing was carried out during the tail end of a thunderstorm which is generally accompanied by big changes of potential gradient.
5. The mooring cables absorbing more and more rain became intensified conductors.

These five causes have been reproduced in the laboratory and electrical ignition has been reproduced.

Attention is called to the Echterdingen disaster (1908) which was probably due to the same cause.

Full Automatic Blind Landing System. The Landing System Developed by the U.S. Army. (Inter. Avia., No. 484, 26/10/37, pp. 1-2.) (49/62 U.S.A.)

The U.S. Air Corps system incorporates a relay connection between the Fairchild radio compass and the Sperry automatic pilot. In addition, the engine throttle is actuated by radio and a sensitive altimeter and on touching ground the throttle is closed and the wheel brakes operated through the action of the landing gear strut. The ground installation consists of 3-5 low range non-directional radio beacons of staged frequencies within 200-400 kc.; each of these beacons is supplemented by a two-beacon (ultra short wave) vertical marker. The landing procedure is as follows:—

When flying over the two beacons, the throttle is actuated in accordance with the change in altitude required and the radio compass receiver is set to the frequency of the next radio beacon. When arriving over the last beacon but one, the aeroplane goes into a glide, the throttle being adjusted by the altimeter to give a constant downward vertical velocity. During the glide the radio compass maintains the course to the last beacon.

Sudden Disturbances of the Ionosphere. (J. H. Dellinger, Proc. Inst. Rad. Eng., Vol. 25, No. 10, Oct., 1937, pp. 1253-90.) (49/63 U.S.A.)

The radio and magnetic effects have been shown to be of a distinct type, quite different from previously known vagaries in these fields. They are of maximum intensity in that region of the earth where the sun's radiation is perpendicular.

Many of the occurrences are simultaneous with great eruptions on the sun. Such eruptions emit vast quantities of ultra violet light. These radiations are sometimes of such frequencies as to cause intense ionisation of part of the ionosphere below the E. layer. This sudden ionisation causes the radio and other perturbations. Their characteristics are explained. Study of this effect is leading to new understanding of the nature of the ionosphere, the processes of radio wave transmission, the mechanisms of terrestrial magnetism, and the phenomena occurring in the sun.

Field Strength Observations of Transatlantic Signals, 40 to 45 Megacycles. (H. O. Peterson and D. R. Goddard, Proc. Inst. Rad. Eng., Vol. 25, No. 10, Oct., 1937, pp. 1291-9.) (49/64 U.S.A.)

The results of daily observations at Riverhead, L.I., N.Y., since the middle of January, 1937, are reported. Some of the schedules of London and Berlin television transmissions are reported as being heard and measurements of field strengths are summarised. The vertical angle of arrival was measured and by means of a reversible directive antenna it was determined that the signal at times arrives from a direction other than that of the great circle path through London and Riverhead.

Some Notes on the Milan Exhibition by a French Designer. (Les Ailes, No. 854, 28/10/37, pp. 8-9.) (49/65 France.)

The following points were specially noted:—

1. The general use of light castings (both light alloy and steel) on the German machines.
2. Both Italian and German machines are designed specifically for mass production.

3. High wing loading necessitates general use of slotted flaps (special mention of Piaggio double slotted flap).
4. Messrs. Piaggio and Fiat are stated to have a monthly output of 600 engines between them. (Special mention is made of the Piaggio P.XII 18-cylinder engine, 1,600 b.h.p.)

Prizes Offered by the Lilienthal Society. (Flugsport, Vol. 29, No. 22, 27/10/37, pp. 622-624.) (49/66 Germany.)

Prizes are offered by the Society for the best articles submitted by German authors on the following subjects:—

1. Type of air flow round an aerofoil under unsymmetrical conditions (oblique attack, sideslip, rotation, etc.).
2. Vibration and distribution phenomena in induction system of carburettor engines with special reference to valve timing.
3. Critical survey of proposed methods of measuring altitude of aircraft and distance of obstacles by means of wireless waves.
4. Ballistic requirements of high speed aerial gunnery.

Prizes to the total value of RM.2,400 are offered in each subject and the latest date of entry is August 1, 1938.

PIN-JOINTED STRUTS.

By L. H. Sumanadasa, B.Sc., A.C.G.I., D.I.C.

Simplified method of solution of the equation,

$$p = p_y / [1 + (d\delta/2k^2) \sec \{ (l/2k) \sqrt{(p/E)} \}] \quad . \quad . \quad . \quad (1)$$

where p = the permissible stress.

p_y = proof stress.
d = external diameter of strut.
k = radius of gyration.
l = length of strut.
δ = eccentricity.
E = Young's modulus of elasticity.

This method is mainly developed in order to reduce the time taken to work out a series of curves of permissible stress against (l/k). The graphical methods have so far been elaborate and no definite accuracy can be maintained.

The following method gives the result much more readily.

Let

$$1/\sqrt{x} = (l/2k) \sqrt{(p/E)}$$

$$i.e., \; x = 4E/p\,(l/k)^2 \text{ or } p = 4E/x\,(l/k)^2$$

Substituting in the above equation

$$4E/x\,(l/k)^2 = p_y/[1 + (d\delta/2k^2) \sec 1/\sqrt{x}]$$

or

$$1 + (d\delta/2k^2) \sec (1/\sqrt{x}) = \{ (l/k)^2 p_y/4E \}\, x \quad . \quad . \quad . \quad (2)$$

put

$$A = d\delta/2k^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$B = (p_y/4E)\,(l/k)^2 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The equation (2) reduces to

$$1 + A \sec 1/\sqrt{x} = Bx$$

$$i.e., \; \sec 1/\sqrt{x} = Bx/A - 1/A \quad . \quad . \quad . \quad . \quad (5)$$

Now consider the equation $y = \sec 1/\sqrt{x}$. When y varies from 1 to ∞, $1/\sqrt{x}$ varies from 0 to $\pi/2$, *i.e.*, x varies from ∞ to $4/\pi^2$.

Hence the equation $y = \sec 1/\sqrt{x}$ can be put in the form

$$(y - 1)\,(x - 4/\pi^2) = c$$

for values of c, see Appendix I,

$$i.e., \; (\sec 1/\sqrt{x} - 1)\,(x - 4/\pi^2) = c \quad . \quad . \quad . \quad . \quad (6)$$

From (5) and (6)

$$(Bx/A - 1/A - 1)\,(x - 4/\pi^2) = c \quad . \quad . \quad . \quad . \quad (7)$$

$$i.e., \; (Bx - 1 - A)\,(x - 4/\pi^2) = cA$$

$$i.e., \; Bx^2 - (1 + A + 4B/\pi^2)\,x + (1 + A)\,(4/\pi^2) - cA = 0$$

$$i.e., \; x = (1/2B)\,[(1 + A + 4B/\pi^2) \pm \sqrt{\{(1 + A + 4B/\pi^2)^2 - 4B\,[4\,(1 + A)/\pi^2 - cA]\}}]$$

put

$$C = 1 + A + 4B/\pi^2 \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$D = 4B\,[4\,(1 + A)/\pi^2 - cA] \quad . \quad . \quad . \quad . \quad (9)$$

Hence

$$x = (1/2B)\,[C \pm \sqrt{(C^2 - D)}] \quad . \quad . \quad . \quad . \quad (10)$$

For positive values of x

$$x = (1/2B)\,[C + \sqrt{(C^2 - D)}] \quad . \quad . \quad . \quad . \quad (11)$$

Substituting for x and B in equation (11)

$$4E/\{p(l/k)^2\} = \{4E/2p_y(l/k)^2\}\{C+\sqrt{(C^2-D)}\} \quad . \quad . \quad (12)$$

$$i.e.,\ p = 2p_y/\{C+\sqrt{(C^2-D)}\} \quad . \quad . \quad . \quad (13)$$

Hence, knowing the values of C and D the permissible stress p can be calculated.

Appendix I.

The following table gives the value of c for various values of $1/\sqrt{x}$ as calculated from the Natural Secant Tables:—

$1/\sqrt{x}°$	$1/\sqrt{x}$ radians	x	$y-1$	$x-4/\pi^2$	c
5	0.08727	$1296/\pi^2$	0.00382	$1292/\pi^2$	0.50005
10	0.17453	$324/\pi^2$	0.01543	$320/\pi^2$	0.50024
15	0.26180	$144/\pi^2$	0.03528	$140/\pi^2$	0.50042
30	0.52360	$36/\pi^2$	0.15470	$32/\pi^2$	0.50152
45	0.78540	$16/\pi^2$	0.41421	$12/\pi^2$	0.50360
60	1.04720	$9/\pi^2$	1.00000	$5/\pi^2$	0.50659
75	1.30900	$144/25\ \pi^2$	2.8637	$1.76/\pi^2$	0.51067
80	1.39626	$81/16\ \pi^2$	4.7588	$17/16\ \pi^2$	0.51227
85	1.48353	$1296/289\ \pi^2$	10.474	$140/289\ \pi^2$	0.51400

Hence, from this table the value of c can be taken to be almost a constant, except in the case of $1/\sqrt{x}$ approaching $\pi/2$.

For a first approximation take $c = 0.51$ then

$$D = 4B\,[4(1+A)/\pi^2 - cA]$$

gives

$$D = (4B/\pi^2)(4 - 1.034A)$$

Appendix II.

Example.

Consider a tubular strut made of material T-45, where

$$E = 30{,}000{,}000 \text{ lbs./sq. in.}$$

$$p_y = 89{,}600 \text{ lbs./sq. in.}$$

Take

$$\delta = l/600 + d/40$$

Hence it can be shown that for small gauge values

$$d\delta/2k^2 = (\sqrt{2}/600)(l/k) + 1/10$$

$$A = (\sqrt{2}/600)(l/k) + 0.100$$

$$B = (p_y/4E)(l/k)^2 = (89{,}600/4 \times 3{,}000{,}000)(l/k)^2$$

$$= (1/1339)(l/k)^2.$$

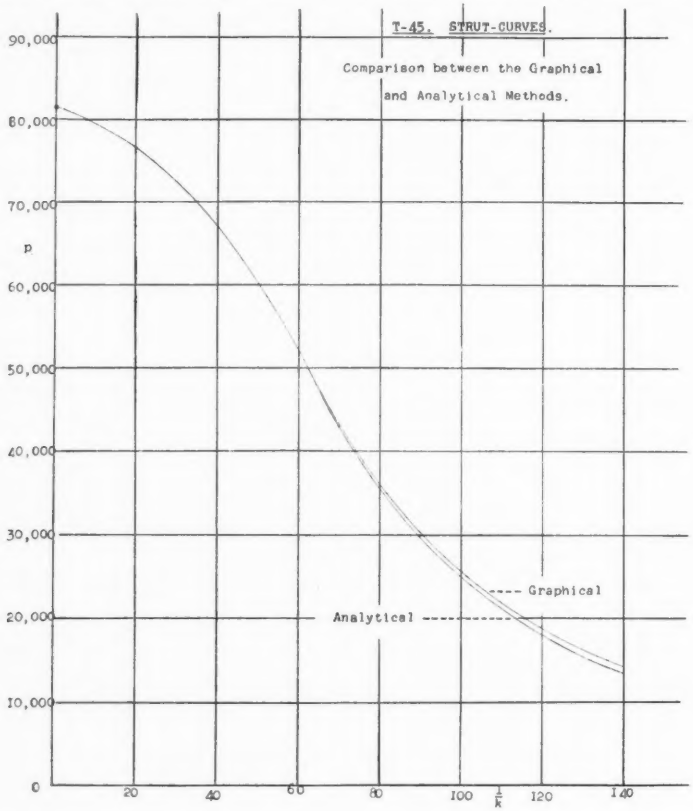
The following table is filled for various values of l/k, C and D are taken as in Appendix I.

(1) l/k	(2) A	(3) B	(4) $4B/\pi^2$	(5) C	(6) $1.034A$	(7) $4\text{-}1.034A$	(8) D	(9) C^2
0	0.100	0	0	1.10	0.1034	3.897	0	1.21
20	0.147	0.298	0.121	1.268	0.152	3.848	0.465	1.61
40	0.1943	1.195	0.485	1.679	0.202	3.798	1.845	2.82
60	0.242	2.69	1.090	2.332	0.250	3.750	4.09	5.43
80	0.289	4.78	1.935	3.224	0.299	3.701	7.16	10.35
100	0.336	7.47	3.03	4.37	0.348	3.652	11.05	19.1
120	0.383	10.75	4.35	5.73	0.396	3.604	15.7	32.8
140	0.430	14.65	5.93	7.36	0.445	3.555	21.1	54.2

	(10)	(11)	(12)	(13)	(14)	(15)
l/k	C^2-D	$\sqrt{(C^2-D)}$	$C+\sqrt{(C^2-D)}$	$2/\{C+\sqrt{(C^2-D)}\}$	p calc.	p graphical
0	1.21	1.1	2.20	0.91	81,500	81,500
20	1.145	1.07	2.338	0.855	76,600	76,600
40	0.975	0.987	2.666	0.748	67.100	67,000
60	1.34	1.16	3.49	0.573	52,200	52,000
80	3.19	1.786	5.01	0.400	35,800	36,000
100	8.05	2.84	7.21	0.277	24,800	25,500
120	17.1	4.14	9.87	0.203	18,200	19.000
140	33.1	5.76	13.12	0.1525	13,650	14,200

The above example gives an idea of the accuracy of the method adopted. For the sake of comparison I have given in column (15) the values of p as found by the graphical method.

In order to get more accurate results for p for values of l/k greater than 100, the constant c has to be modified. Hence, for higher values of l/k take $c=0.515$.



SUMMARY OF THE SOCIETY'S ACTIVITIES,

DECEMBER, 1936—DECEMBER, 1937.

The following places on permanent record in the Journal the notices which have appeared in the Monthly Notices and so summarises the activities of the Society for the year. Activities not reported in the Summary will be given in the Annual Report of the Council which will be published in the Journal for March, 1938.

ANNUAL GENERAL MEETING.

The Annual General Meeting of the Society was held on Wednesday, March 31st, 1937, in the Library at 7, Albemarle Street, London, W.1, at 6.30 p.m.

Present:

Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S. (President), in the chair.

R. F. Bailey (Associate Fellow).
Griffith Brewer (Hon. Fellow).
Major G. P. Bulman (Fellow).
J. G. Campbell (Associate Fellow).
H. Roxbee Cox (Fellow).
M. J. B. Davy (Fellow).
W. C. Devereux (Fellow).
W. E. Gray (Companion).
J. C. Hardman (Student).
F. T. Hill (Fellow and Member).
C. H. Jackson (Associate Fellow).
R. Glyn Jones (Associate Member).
Major D. H. Kennedy (Fellow, Honorary Treasurer).
Miss A. Kennedy (Companion).
J. E. G. Labey (Associate Fellow).
W. O. Manning (Fellow).
H. A. Mettam (Fellow).
P. P. Nazir (Associate Fellow).
A. J. Sutton Pippard (Fellow).
L. F. Plugge (Fellow).
R. W. Potts (Associate).
A. F. Walsh (Student).
Lawrence A. Wingfield (Associate, Solicitor).

Captain J. Laurence Pritchard (Secretary).

1. Before commencing the business on the Agenda, the President announced that His Majesty the King had been graciously pleased to become Patron of the Society.

2. The Secretary read the notice convening the meeting.

3. The President briefly reviewed the Annual Report and Balance Sheets for 1936, as members had had copies in the March Journal and also had copies before them. He drew the attention of those present to the increase of membership during the year and that there was every prospect of a substantial increase in 1937. Members could see that the Endowment Fund now stood at £11,138 16s. 7d., and the President reported that the Development Committee had been assiduously at work to increase this figure.

With regard to the Branches, the President hoped to visit the Canadian and Australian Branches during his forthcoming tour.

The Journal Account was shown to be very satisfactory, the President pointing out that it was hoped to improve the Journal in the very near future, mainly by publishing more articles on research work.

After commenting on the paragraph dealing with Finance, the President invited members to make any comments they wished on the Report and Balance Sheet.

4. Mr. W. E. Gray (Companion) pointed out that in the Balance Sheet the items "Dinners and Receptions" almost equalled "Meetings," and as the

meetings were the more important function of the Society he would like to see a change of venue as the present lecture hall was inadequately ventilated.

The President replied that with the increase in membership it was hoped to hold the lectures at the Institution of Electrical Engineers, where a more adequate lecture theatre was available.

Mr. L. A. Wingfield (Associate, Solicitor) referred to the uninvested funds in the various Prize Funds shown in the Aeronautical Trusts Balance Sheets, and suggested these accumulated funds be invested.

Major Kennedy (the Honorary Treasurer) promised that the matter would be considered by the Finance Committee at their next meeting.

Mr. P. P. Nazir (Associate Fellow) suggested that the Society's proposed increased activities should include advice at a reasonable cost on new inventions placed before them.

Professor Pippard (Fellow) pointed out that was the work of consultants and not the function of the Society.

The President said that the Government already provided facilities for such advice through the Aeronautical Research Committee, and that there were probably constitutional difficulties why the Society could not undertake such work.

The discussion then concluded on the Annual Report of the Council.

5. The President then presented the Report of the Scrutineers of the Ballot for the Council as follows:—

Mr. Robert Blackburn.
Major G. P. Bulman.
Mr. H. Roxbee Cox.
Mr. A. H. Hall.
Professor G. T. R. Hill.
Lieut.-Colonel W. Lockwood Marsh.
Dr. N. A. V. Piercy.
Mr. D. R. Pye.
Mr. E. F. Relf.
Sir Francis Shelmerdine.

The Scrutineers were thanked for their work in counting the votes for the Council ballot.

6. It was proposed by Mr. W. O. Manning and seconded by Professor A. J. Sutton Pippard, that Messrs. Price, Waterhouse be re-appointed Auditors of the Society's accounts for the forthcoming year. The proposal was carried unanimously.

7. The alteration of Rule 35*a* to read "Graduates shall be persons not under 21 years of age, and not more than 28 years of age," was proposed by Mr. H. Roxbee Cox and seconded by Professor F. T. Hill. The proposal was carried unanimously.

8. The alteration of Rule 57 (Appendix-Subscriptions) Section 1, Line 6, to read as follows:—

	Home.	Abroad.	
Graduates ...	£2 2s. od.	£2 2s. od.	(age 21-25)
	£2 12s. 6d.	£2 12s. 6d.	(age 26-28)

was proposed by Mr. W. O. Manning and seconded by Miss Alice Kennedy.

An amendment was proposed by Mr. Roxbee Cox and seconded by Professor Pippard that the age limit be more clearly defined. The following Resolution was passed:—

"That the alteration to Rule 57 proposed as modified by Mr. Roxbee Cox's amendment, which has been carried unanimously, be adopted."

It was proposed by Mr. Roxbee Cox and seconded by Major G. P. Bulman that the proposal to increase Entrance Fees of Fellows and Members from £3 3s. od. to £5 5s. od. be adopted. The proposal was carried unanimously.

The consequential alteration of the Transfer Fees were accordingly adopted unanimously.

The President then declared the meeting open for discussion of any other business.

9. Mr. W. E. Gray (Companion) put the following Resolution to the Meeting :—

> " That the Council use its utmost influence with the Air Ministry and the Aeronautical Research Committee to secure a drastic speeding-up in the publication of the results of public research."

The President said he could answer the point regarding the more speedy publication of Reports and Memoranda. The policy is that when Reports on Research Work are issued in typewritten form they are then circulated to the entire British aircraft industry and a year or so later general publication is authorised. The price of the Reports compared with Reports of a similar nature of the N.A.C.A. The President pointed out that the policy in the United States was different from that obtaining here.

Mr. Jackson (Associate Fellow) and Miss Kennedy (Companion) said that only Senior Technical Staffs in firms were allowed to see the Reports and Memoranda and that owing to the heavy cost Junior Staffs were unable to afford them.

Professor Pippard pointed out that the charge is based on the cost of production and the number of copies sold.

Mr. Devereux reported that the policy of his firm was to have all Reports abbreviated and sent round to the whole of the technical staff, who could ask for any particular publication or the Report in full.

Mr. Wimperis reminded members that the Society prints regularly Abstracts from the Scientific and Technical Press and that most of the publications from which the abstracts are made are available in the Library of the Society.

Professor Pippard said he was able to obtain all Stationery Office Publications at 50 per cent. of the published price.

Mr. M. J. B. Davy suggested that the Society should stimulate the demand for the Reports and Memoranda and so reduce the price.

Mr. Jackson suggested the Society should try to obtain special concessions for Graduates and Student Members.

The President instructed the Secretary to explore the various suggestions.

Mr. P. P. Nazir (Associate Fellow) seconded the Resolution put forward by Mr. W. E. Gray.

The President then announced that the Resolution would be brought before the Council of the Society for discussion.

Mr. Griffith Brewer (Honorary Fellow) moved a vote of thanks to the President for his able conduct of the meeting and congratulated him on the wonderful progress of the Endowment Fund. He added that he would be sure all members present would like the President to take their good wishes with him on his forthcoming visit to Canada and Australia.

The meeting terminated at 7.45 p.m.

ELECTION OF PRESIDENT.

Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S., was re-elected President of the Society for the year 1937-1938 by the Council.

VICE-PRESIDENTS.

The following Vice-Presidents were elected by the Council :—

Mr. F. Handley Page, C.B.E., F.R.Ae.S.
Mr. A. H. R. Fedden, M.B.E., M.I.A.E., M.S.A.E., F.R.Ae.S.
Mr. A. H. Hall, C.B., C.B.E., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. D. R. Pye, C.B., M.A., M.I.Mech.E., F.R.Ae.S.

NEW YEAR'S HONOURS.

K.C.B.

Henry Thomas Tizard, Esq., C.B., A.F.C., F.R.S. (Fellow of the Society).

C.B.

Arthur Henry Hall, Esq., C.B.E. (Fellow of the Society).

A.F.C.

Flt. Lieut. Cyril Frank Uwins (Associate Fellow of the Society).

CORONATION HONOURS.

Baron.

Sir John Siddeley, C.B.E., J.P. (Fellow of the Society).

C.B.

D. R. Pye, Esq., M.A., Sc.D., M.I.Mech.E., F.R.Ae.S. (Fellow of the Society).

ELECTIONS.

On December 8th, 1936:—

Fellow.—Albert Percival Rowe.

Associate Fellows.—William Gee Bickley, Carl Robert Chronander, William Edgar Noel Clark, Harold Basset Collins, George William Jones, Edgar George Vardy, Leonard William Warner, Patrocle John Yangos.

Associate Members.—Ernest Dudley Johnson, John Percival Pryer.

Students.—Frank Allsopp, Stanley Mark Angel, Arthur Kenneth Baker, Harry Charles Netterville Barron, Edward Noel Brailsford, Edmund John Cardell, Jack Appleton Channer, Roy Derek Cullum, John Dubbury, Jas. Ferguson Gibbon, Leslie William Ivey, John Leslie Longden, John Marshall McAlonan, Edwin Arthur Nash, Arthur Sydney Robins, Joseph Leonard John Rowland, James Walter Scott, John Cyril Knowles Shipp, Thomas Ernest John Solby, Leslie Sykes, Howard Buckley Wilkinson, Ronald Bartlett Wilkinson.

Companions.—Ernest Folley, Erach Godivala, Herbert Kimber, Miss Alice Grainger Stewart.

On January 19th, 1937:—

Fellows: M. J. B. Davy, G. H. Dowty, D. McL. Ferrier, R. A. Watson Watt.

Associate Fellows: J. C. Brooke, J. Dobson, W. J. Goodey, C. Hayes, Miss E. M. G. MacGill, J. G. Nagle, J. A. Vigil, C. Carr Young.

Associate Members: W. A. Conley, R. Hollingworth.

Associates: D. A. R. Clark, H. E. Francis-Stead, K. R. Imeson.

Students: H. Barnes, J. B. Bucher, A. L. Fermor, M. D. Gibson, V. C. Gunn, C. Horsfield, S. Hyde, J. J. Kaye, D. R. Newman, J. B. Sheldon, M. H. Sheward, R. Smelt, E. Swingler, B. E. Treganowan, G. E. L. Walker, J. M. T. Woodcock.

Companions: C. D. Stanley, Whitney W. Straight.

On February 9th, 1937:—

Fellows.—Wallace Charles Devereux (from Associate Fellow), Frank Morgan Owner (from Associate Fellow).

Associate Fellows.—William Claude Cooper, Herbert Marcus Kemp, Robert Lang Lickley, Neil Shaw Muir, Miles Craven Rigby.

Associate.—John Gilbert McDonald.

Students.—Lionel Oscar Barnett, Dennis Bernard Clifford, George Henry Corbett, Eric Thomas Davies, Robert Niles East, William Harvey Hankin, Kenneth Walter Hetzel, Dennis Charles Jenkins, George Percy Jewell, Joseph Guy Lubbock, Basil M. Marsh, Lionel William Martin Nex, James Ronald Plenderleith, Harry Verdun Ramster, William Arthur Jevons Street, Leonard George Arthur Turner.

Companions.—Francis Gordon Tilstone Dudgeon, Eric Alexander Dorling, Robin Arthur Grosvenor, Douglas Maurice Limbery, Maldon Cavendish Harley.

On March 16th, 1937:—

Associate Fellows.—J. G. Brown, F. G. Gardner, E. J. Gregson, F. Hauptmann, W. M. Page, J. H. Preston, G. Silyn Roberts, F. T. Watts, G. B. Vinycomb.

Associate Members.—M. G. Hunn, W. W. T. Sawyer.

Associates.—R. K. B. Bridges, Alan S. Butler, A. E. McLaren, E. S. Millett.

Students.—H. Clark, W. H. Coulthard, K. R. Davies, H. A. G. James, A. W. H. Jamieson, J. K. Keelaghan, J. P. Lassam, R. Maine, J. K. Marshall, J. B. Mills, R. M. Leach, H. G. S. Peacock, J. Phillips, W. H. Riley, H. G. W. Turner, P. P. Whaley.

Companions.—Lieut.-Col. M. O. Darby, Alexander Gross, A. O. Pollard, R. A. Robbins, A. M. Tucker.

On April 12th, 1937:—

Fellows.—T. P. Wright, W. G. Carter.

Member.—A. R. Code.

Associate Fellows.—H. St. G. Burke, H. Cantrill, W. H. Golder, A. W. B. McDonald, W. F. Pharazyn, H. V. Rowley, C. Turner, E. W. C. Wilkins.

Associate Members.—W. H. Brooks, E. F. Carpenter, R. J. Fyfe, E. Holden, J. A. Sheppard.

Associates.—F. D. Aldridge, A. D. Ferguson.

Students.—M. C. Goodall, S. R. Lewis, H. M. Will.

Companions.—A. R. Hallock, G. S. Morrison.

On May 25th, 1937:—

Fellow.—Thomas Swinden (from Associate Fellow).

Associate Fellows.—John Allan Beavan, Hedley S. Crabtree, Robert Victor Goddard, John Malcolm Gray, Leslie Milkington Iles, Masaiti Kondo, Laurence Thomas George Mansell, Frederick William Meredith, Thomas Pitt de Paravicini, George Parkin, Arthur Alexander Rubbra, Tom Roberts Thomas, Ernest William Howarth Thompson, Harry Wood.

Associate Member.—Edwin Sidney Street.

Associate.—John Stanley Orme.

Graduate.—Roland Towers.

Students.—Jack William Guy Comfort, Sidney Graham Heath, Daniel McQueen, James Cedric Paterson, John Bodan Ross, Gervase Robinett Scruby.

Companions.—Freeman Horn, Cyril Campbell Login, Hetman Jack Parham, Dady Rustum Wadia.

On June 8th, 1937:—

Fellow.—Thomas George John.

Associate Fellows.—Richard Cox Abel, Frederick George Liddiard Amer, Harold John Cardnell Harper, Chih-Bing Ling, Albert James Mott, Sydney Joseph Nightingale, Richard Arthur Robbins, Edward Tyler, James Henry Winch.

Associate Members.—John Fort, John Desmond Loraine Stratton.

Associates.—Henry Charles Brown, Frank Holliday, Lewis Larsen.

Graduates.—Stewart Kevern Hambling, Edward Loveless, Peter Herbert Rayner.

Students.—Eric Raymond Arbon, Suriel Kumar Banerjee, Peter Crolla, Albert Leonard Bryant, Wilfred Barwell Holroyd, John Anthony McGoff, George Harold Thomas.

Companion.—Mrs. Walker Sinclair.

On September 14th, 1937:—

Fellow.—Alan Newell Clifton (from Associate Fellow).

Associate Fellows.—John Diedrich Ahlers, Philip Andrew Cooke, Hugh John Curnow, Reginald Edgar Gilbert Fulljames, Eric Grundy, Richard Manners Heldson, James Leonard Barnard Jones, John Parry Jones, Bernard Victor Leak, John Francis Xavier McKenna, John Richard Morgan, Norbert Edward Rowe, Cyril Hector Gibson Soper, Percival Nesbit Willoughby.

Associate Members.—Charles Rennie Paul Bizeray, Wilfred George Coombes, Caradoc Howell Evans, Joannes Jozef Granzier, Thomas Charles Hey, Jack Kenneth Woolgar Wheatley.

Associates.—Charles Leslie Best, Reginald Arthur Burton, John Alfred Choate, Charles Martyn Collard, Vincent Neville Dickinson, Eric Edwin Hedgcock, Albert Herbert William Kydd, Herbert Basil Goldwyer Michelmore, Charles Willard Miller, Joseph William Trevelyan, Victor Harold Wentworth, Esmond Birdsall Wilshire.

Graduates.—John Edgar Boast, Hugh Tempello Grigg, Hsueh-Chang Pang, George Maclaren Humphreys, Ralph Harry Price, Eric Raymond Staniland, Alan Frederick Walsh, Charles Harold Wigg.

Students.—Walter Henry Bewg, James Phipps Booth, Kenneth George Dunn, Allen Harold Claude Greenwood, Stewart Douglas Hall, Allan John Hancock, Douglas James How, Brian Ruckman Hutchinson, Harry Bertram Hallam Judd, Philip de Lacy Markham, Victor William John Prince, Norman Francis Rowe, George Smith, Kenneth John Spooner, Charles Roger Tennant, Jack Percival Thompson, Thomas Henry Whitehouse.

Companions.—Ronald Merriman Barry, Neil McLeod Gibson, Wallace Eric Locke, Alfred James Spilman.

On October 19th, 1937:—

Fellow.—James Douglas Haddon (from Associate Fellow).

Member.—Charles William Ernest Browse (from Associate Member).

Associate Fellows.—Arthur Beavan, Thomas Stanley Davies Collins, Alex Arthur Fletcher, Jack Hanson, Cecil Reuben Hall Johnson, Neville Durrant New, Leslie Rendall Parkinson, John Henry Payne, Alfred Grenvile Pugsley, Glyndwr Rees, Frederick William Victor Webber.

Associate Members.—Glyn Ashfield, Arthur MacHiven Brown, William Howarth Downey.

Associates.—Oscar Reginald Rowe, Victor William Steele, John Wimperis.

Graduates.—Geoffrey Dean Dawson, Ian Gair Duncan, Kenneth Calvert Hales, Ernest Rose, Lokusatu Heva Sumanadasa.

Students.—Peter Charles Armour, Laurence Sydney Edwards, John Roy Ewans, Guy Clavell Inge Gardiner, Trevor Harold Gilbert, Donald Hill, John Hawke Horsfield, Ronald Samuel Hughes, David William Kew, Godfrey Henry Lee, David Basil Gerald Miles, Anthony Basil Pippet, Sidney James Pope, David Harry Robbins, Henry Roberts, Frank Desmond St. Hilaire, Vivian Egerton Saunders, Leonard Smith, Walter John Revill Stocks, Cyril Ernest Weeden, Kenneth Grahame Wilkinson.

On November 9th, 1937:—

Associate Fellows.—Bruce McArthur Foster, Clifford John Price, John Benjamin Brynmar Owen, Henry Phillips, Thomas Rowntree.

Associate Member.—Roy Champion Kean, Arthur Vicary Hunter.

Associates.—John Roy Cotton, Walter Frederick Locke.

Graduates.—Alfred Herbert Aylwin Bastable, George Henry Macmillan Birkbeck, Ralph Cuthbert Chisholm Brown, David Ketchen Marshall, John George Magrath Pardoe, Edgar Allen Stroud.

Students.—John Edwards Adamson, Francis Stanley Burt, Harim Daniel Tabakman, George Steedman Hislop, Robin Piercy, Thomas David Weston Ross.

Companion.—Caspar John.

ASSOCIATE FELLOWSHIP AND ASSOCIATE MEMBERSHIP EXAMINATIONS.

The following candidates were successful in the December, 1936, examinations:

ASSOCIATE FELLOWSHIP EXAMINATION.

K. W. Hetzel	Applied Mathematics (1st place tied). Theory of Internal Combustion Engines (1st place). Aircraft Materials.
F. J. Horn	Pure Mathematics.
D. I. Husk	Applied Mathematics (1st Place tied). Theory of Internal Combustion Engines. Aircraft Materials (1st place).
F. H. M. Lloyd ...	Applied Mathematics (1st place tied). Design (Aircraft).
R. S. Lloyd	Applied Mathematics. Aircraft Materials.
D. Milne	Design (Aircraft). Aerodynamics (1st place).
H. G. S. Peacock ...	Applied Mathematics.
R. Towers	Applied Mathematics. Theory of Internal Combustion Engines. Design (Aero Engines).
A. P. West	Aerodynamics.
M. B. Williams ...	Pure Mathematics. Aircraft Materials.

ASSOCIATE MEMBERSHIP EXAMINATION.

S. J. G. French ...	Applied Mathematics (1st place). Theory of Internal Combustion Engines. Aircraft Materials (1st place.)
T. A. Gawade ...	Applied Mathematics. Theory of Internal Combustion Engines (1st place). Aircraft Materials.
R. G. S. Hogarth ...	Applied Mathematics. Theory of Internal Combustion Engines. Aircraft Materials.
C. F. Mervyn-Jones ...	Applied Mathematics. Theory of Internal Combustion Engines. Aircraft Materials.
W. J. M. Moss ...	Applied Mathematics. Theory of Internal Combustion Engines. Aircraft Materials.
C. G. Saunders ...	Theory of Internal Combustion Engines.
W. W. Sayers ...	Applied Mathematics.

The following candidates were successful at the examinations held in May, 1937:—

ASSOCIATE FELLOWSHIP.

J. L. Burbidge ...	Applied Mathematics (First Place). Theory of Internal Combustion Engines. Design (Aero Engines).
D. A. Clifton-Mogg ...	Applied Mathematics.
A. E. Draper	Pure Mathematics.
H. M. Gardiner ...	Theory of Internal Combustion Engines. Design (Aero Engines).
M. A. F. Hirst ...	Pure Mathematics (First Place). Aerodynamics. Design (Aircraft).
D. M. Jameson ...	Theory of Internal Combustion Engines (First Place)
B. V. Leak	Applied Mathematics. Strength of Aeronautical Materials. Design (Aircraft).
F. H. M. Lloyd ...	Strength of Aeronautical Materials.
C. H. Nundy	Strength of Aeronautical Materials.
H. G. S. Peacock ...	Strength of Aeronautical Materials. Aerodynamics.
F. H. Pollicutt ...	Pure Mathematics. Strength of Aeronautical Materials (First Place). Design (Aircraft) (First Place).
C. A. Ridgwell ...	Pure Mathematics. Aerodynamics.
J. Smith	Aerodynamics.
R. Towers	Aircraft Materials.
W. A. C. Weetman ...	Strength of Aeronautical Materials. Design (Aircraft).
A. P. West	Pure Mathematics.
M. B. Williams ...	Theory of Internal Combustion Engines.
P. N. Willoughby ...	Applied Mathematics.
E. A. Wright	Aerodynamics (First Place).

Associate Membership.

C. R. P. Bizeray	...	Strength of Aeronautical Materials.
F. G. T. Dudgeon	...	Theory of Internal Combustion Engines. Aircraft Materials.
F. Kendall ...	...	Applied Mathematics. Strength of Aeronautical Materials. Design (Aircraft).
K. C. T. Marshall	...	Applied Mathematics (First Place).
R. C. Pike ...	...	Applied Mathematics.
C. G. Saunders	...	Aircraft Materials.

Wilbur Wright Memorial Lecture.

The 25th Wilbur Wright Memorial Lecture was delivered by Professor von Kármán on "Turbulence," on May 27th, 1937. A report appears on page 1108.

Conversazione.

On January 12th, 1937, the President (Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S.) and the Council of the Society held a Conversazione in the Science Museum (Aeronautical Section), South Kensington, to commemorate the 71st Anniversary of the founding of the Society. The guests were received by the President and Mrs. Wimperis. Among those who accepted invitations to be present were the following:—

Major G. H. Abell, O.B.E., A.F.R.Ae.S.; Mrs. G. H. Abell; A. S. E. Ackermann, Esq., B.Sc.; — Adache, Esq.; Capitaine de Corvette V. A. M. Albertas (Air Attaché, French Embassy); Madame Albertas; Monsieur P. Alberts (Secretary, Latvian Legation); Madame Alberts; E. S. Allwright, Esq., A.C.G.I., B.Sc., D.I.C.; — Andreae, Esq.; W. R. Andrews, Esq., A.F.R.Ae.S.; Mrs. Appleby; Senor Don E. Eduardo Aramayo (Secretary, Bolivian Legation); Captain E. O. Armytage; Captain Natal Arnaud (Naval Attaché, Brazilian Legation); Madame Arnaud.

Colonel Sir Donald Banks, K.C.B., D.S.O., M.C. (Secretary of the Air Ministry); Lady Banks; F. Rodwell Banks, Esq., O.B.E., M.I.A.E., F.R.Ae.S.; Mrs. Rodwell Banks; Major T. M. Barlow, M.Sc., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.; Captain F. S. Barnwell, B.Sc., O.B.E., A.F.C., F.R.Ae.S.; F. S. Barton, Esq.; Miss F. Barwood; E. L. Bass, Esq., A.F.R.Ae.S.; Mrs. E. L. Bass; H. Bateman, Esq., A.C.G.I., B.Sc., D.I.C., A.F.R.Ae.S.; Mrs. Bateman; Squadron Leader H. F. V. Battle, D.F.C., A.F.R.Ae.S.; F. A. C. Behenna, Esq.; Hans Belart, Esq., A.F.R.Ae.S.; Flight Lieut. J. C. Belford; Revill Bellamy, Esq.; Monsieur H. C. Berg (Counsellor, Norwegian Legation); Professor P. M. S. Blackett, M.A., F.R.S.; Mrs. Blackett; E. E. Blount, Esq.; F. G. Boreham, Esq., A.M.I.Ae.E.; Mrs. M. Boreham; Air Marshal Sir Frederick W. Bowhill, K.C.B., C.M.G., D.S.O. (Air Member for Personnel); Lady Bowhill; I. Bowen, Esq., M.Sc., A.F.R.Ae.S.; Mrs. Bowen; G. V. Boys, Esq., M.A. (Secretary, Institution of Naval Architects); Mrs. G. V. Boys; Miss F. B. Bradfield, M.A., A.F.R.Ae.S.; Air Commodore J. S. T. Bradley, O.B.E. (Director of Equipment, Air Ministry); M. L. Bramson, Esq., A.C.G.I., F.R.Ae.S.; Air Commodore Breese, C.B., A.F.C., F.R.Ae.S.; Major J. S. Buchanan, C.B.E., A.M.I.Mech.E., F.R.Ae.S.; Mrs. Buchanan; R. B. Bridges, Esq.; Major G. P. Bulman, O.B.E., B.Sc., M.I.A.S., F.R.Ae.S.; Mrs. G. P. Bulman; Flight Lieut. P. W. S. Bulman, M.C., A.F.C., F.R.Ae.S.; Mrs. P. W. S. Bulman.

Colonel A. Calderara (Air Attaché, Italian Embassy); Madame Calderara; J. D. Campbell, Esq., B.Sc., A.R.T.C., A.F.R.Ae.S.; Mrs. J. D. Campbell; Miss C. C. Campbell; R. S. Capon, Esq., O.B.E., B.A., F.R.Ae.S.; Mrs. Capon; Lieut. M. G. Casey, B.E., D.I.C., A.F.R.Ae.S.; Dr. T. W. Chalmers;

Air Commodore J. A. Chamier, C.B., C.M.G., D.S.O., O.B.E., A.F.R.Ae.S. (Secretary, Air League of the British Empire); Mrs. Chamier; R. H. Chaplin, Esq., B.Sc., A.F.R.Ae.S.; Miss L. Chitty, F.R.Ae.S.; Brigade Commander I. Cherni (Air Attaché, Soviet Union); Madame Cherni; C. R. Chronander, Esq., B.A., A.F.R.Ae.S.; F. J. Cleveland, Esq., A.M.I.Ae.E.; Squadron Leader S. N. Cole, A.F.R.Ae.S.; W. S. Coleman, Esq., B.Sc., A.C.G.I., D.I.C.; J. V. Connolly, Esq., B.E., A.F.R.Ae.S.; Charles Cooper, Esq.; W. Courtenay, Esq. ("Evening Standard"); Mrs. W. Courtenay; D. J. L. Cowan, Esq.; H. Roxbee Cox, Esq., Ph.D., D.I.C., B.Sc., F.R.Ae.S.; Mrs. D. M. Roxbee Cox.

Robert Dana, Esq.; Mrs. R. Dana; J. H. H. Davison, Esq.; M. J. B. Davy, Esq., A.F.R.Ae.S.; Lieut. Commander A. de Booy (Naval Attaché, Netherlands Legation); W. C. Devereux, Esq., A.F.R.Ae.S.; A. G. H. Diamond, Esq., A.R.Ae.S.I.; D. Cameron Douglas, Esq., A.R.Ae.S.I.; Mrs. D. C. Douglas; Miss M. Douglas, F.R.G.S.; G. P. Douglas, Esq., M.C., D.Sc., A.F.R.Ae.S.; Mrs. G. P. Douglas.

D. L. Ellis, Esq., B.Sc., A.F.R.Ae.S.; Mrs. Ellis; E. C. Gordon England, Esq., F.R.Ae.S.; Mrs. Gordon England.

C. R. Fairey, M.B.E., F.R.Ae.S.; Mrs. C. R. Fairey; Lieut.-Col. L. F. R. Fell, D.S.O., O.B.E., M.I.Mech.E., F.R.Ae.S.; Mrs. L. F. R. Fell; Air Commodore P. F. M. Fellowes, D.S.O., A.R.Ae.S.I.; Mrs. P. F. M. Fellowes; Captain Don Fincati (Naval Attaché, Argentine Embassy), Madame Fincati; Miss Martha Fincati; Miss Esther Fincati; E. G. Fischeles, Esq., A.F.R.Ae.S.; Professor A. Fowler (President, Institute of Physics); Mrs. Fowler; J. M. Furnival, Esq., M.B.E., A.F.R.Ae.S.

Miss D. Gamble; I. J. Gerard, Esq., M.Sc., A.M.Inst.C.E., A.F.R.Ae.S.; Miss N. Gilbert; H. R. Gillman, Esq., A.F.R.Ae.S. (Secretary, Society of British Aircraft Constructors); Mrs. H. R. Gillman; R. Gilmour, Esq.; Miss Alison Grant; Monsieur O. A. Grant (Counsellor, Estonian Legation); E. Granville, Esq.; G. W. T. Gray, Esq.; C. G. Grey, Esq. (Editor, "The Aeroplane"); Mrs. C. G. Grey; P. T. Griffith, Esq., A.F.R.Ae.S.; Commander Holger Grondahl (Naval Attaché, Finnish Legation).

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C. H. Jackson, Esq., A.C.G.I., D.I.C., A.F.R.Ae.S.; Thurstan James, Esq. ("The Aeroplane"); Mrs. Thurstan James; W. G. Jennings, Esq., B.Sc., A.F.R.Ae.S.; Mrs. W. G. Jennings; T. G. John, Esq.; W. E. P. Johnson, Esq., A.F.C., A.F.R.Ae.S.

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E. W. La Borde, Esq., A.R.Ae.S.I.; Dr. G. V. Lachmann, F.R.Ae.S.; Mrs. E. Lachmann; Miss B. Etty-Leal; Sergt. H. Ledger, A.M.I.Ae.E.; Senor Jose E. Ehrman Lefevre (Chargé d'Affaires, Panama Legation); P. C. Lombardini, Esq., A.F.R.Ae.S.; — Longley, Esq.; Mrs. Longley; — Lucas, Esq.; Mrs. Lucas.

G. McAlpine, Esq., M.I.E.E., A.F.R.Ae.S.; Mrs. V. S. McAlpine; Lieut. P. McCormack, B.E., D.I.C., A.F.R.Ae.S.; Colonel E. E. B. Mackintosh, D.S.O. (Director, Science Museum); Miss E. McHardy; Major Maclean; Sir Robert McLean (Chairman, Society of British Aircraft Constructors); W. R. McWilliam, Esq.; J. A. C. Manson, Esq., B.Sc., A.F.R.Ae.S.; Mrs. J. A. C. Manson; Lieut.-Col W. Lockwood Marsh, O.B.E., F.R.Ae.S. (Editor, "Aircraft Engineering"); P. G. Masefield, Esq., B.A. ("The Aeroplane"); Mrs. P. G. Masefield; Vincent Massey, Esq. (High Commissioner for Canada); Mrs. Vincent Massey; H. A. Mettam, Esq., M.A., F.R.Ae.S.; J. H. Millar, Esq., A.R.Ae.S.I.; A. Milligan, Esq.; Mrs. A. Milligan; H. H. Morris, Esq.; Mrs. Morris; Brigadier-General Magnus Mowat, C.B.E. (Secretary, Institution of Mechanical Engineers).

M. Fazlollah Nabil (Secretary, Imperial Iranian Legation); J. L. Nayler, Esq., M.A., F.R.Ae.S.; P. P. Nazir, Esq., A.F.R.Ae.S.; Miss M. Nisessen; Nigel Norman, Esq., F.R.Ae.S.

A. E. Oakham, Esq.; Mrs. A. E. Oakham; The Editor, "The Observer"; Glen Ogilvie, Esq., B.Sc., A.F.R.Ae.S.; Lieut.-Col. H. W. S. Outram, C.B.E., A.R.S.M., A.F.R.Ae.S., A.M.I.E.E., M.I.E.I. (Director of Aeronautical Inspection).

F. Handley Page, Esq., C.B.E., F.R.Ae.S. (Vice-President, Royal Aeronautical Society); Mrs. F. Handley Page; W. M. Page, Esq., C.B.E., M.A. (Director of Educational Services, Air Ministry); Mrs. W. M. Page; Miss J. R. Parkes; R. Pendennis-Wallis, Esq.; Mrs. Pendennis-Wallis; Captain E. W. Percival, M.I.Ae.E.; G. Temple Perkins, Esq., A.R.Ae.S.I.; H. E. Perrin, Esq. (Secretary, Royal Aero Club); Mrs. H. E. Perrin; Major C. E. S. Phillips (Secretary, Royal Institution); Mrs. Phillips; Dr. N. A. V. Piercy, F.R.Ae.S., M.Inst.C.E., M.I.Mech.E., M.Cons.E.; Mrs. Piercy; Captain L. F. Plugge, F.R.Ae.S., M.P.; Monsieur A. G. Politis (Counsellor, Greek Legation); M. Jean Pontremoli, M.S.A.E., F.R.Ae.S.; R. W. Potts, Esq., A.R.Ae.S.I.; C. M. Poulsen (Editor, "Flight"); Press Association Representative; Flight Lieut. R. C. Preston, A.F.C., M.I.Ae.E.; Mrs. Ronald Price; W. H. Primrose, Esq., A.R.Ae.S.I.; H. C. Pritchard, Esq., B.A., A.F.R.Ae.S.; Captain J. Laurence Pritchard, Hon. F.R.Ae.S. (Secretary, Royal Aeronautical Society); D. R. Pye, Esq., M.A., M.I.Mech.E., F.R.Ae.S.; Mrs. D. R. Pye.

Monsieur H. Rabinavicius (Counsellor, Lithuanian Legation); Madame Rabinavicius; K. Redgrave, Esq.; E. F. Relf, Esq., A.R.C.Sc., F.R.Ae.S.; Mrs. E. F. Relf; Senor Don S. Restrepo (Chargé d'Affaires, Colombian Legation); Madame Restrepo; A. H. Reynolds, Esq.; H. Richardson, Esq.; Victor Rickets, Esq. ("Daily Express"); T. B. Ringwood, Esq., A.M.I.Ae.E.; Mrs. Ringwood; E. B. Robinson, Esq., A.F.R.Ae.S.; H. E. J. Rochefort, Esq., Wh. Sch., A.C.G.I., D.I.C.; Captain W. A. Rollason; G. E. Rose, Esq.; A. P. Rowe, Esq., F.R.Ae.S.; Mrs. Rowe.

Lord Sempill, A.F.C., F.R.Ae.S.; the Hon. Ann Forbes Sempill; the Hon. June Forbes Sempill; the Rt. Hon. Sir Philip Sassoon, Bart., G.B.E., C.M.G., M.P. (Under-Secretary of State for Air); W. P. Savage, Esq., A.M.I.Aut.E., F.R.Ae.S.; Colonel M. F. Scanlon (Assistant Military Attaché for Aviation), American Embassy; Mrs. Scanlon; Mrs. Hall Scott; N. Seth, Esq.; G. R. Shaw, Esq.; R. A. Shaw, Esq., A.F.R.Ae.S.; E. Colston Shepherd, Esq. ("The Times"); Mrs. Colston Shepherd; Major B. W. Shilson, O.B.E., M.I.Mech.E., F.R.Ae.S.; H. O. Short, Esq., F.R.Ae.S.; Mrs. Short; A. J. Sidery; L. F. G. Simmons, Esq., M.A., A.R.C.Sc., A.F.R.Ae.S.; Mrs. L. F. G. Simmons; Sir George C. Simpson,

K.C.B., C.B.E., D.Sc., F.R.S. (Director, Meteorological Office, Air Ministry); Lady Simpson; H. G. Small, Esq.; — Smelt, Esq.; Professor R. V. Southwell, M.A., F.R.S., F.R.Ae.S.; Mrs. R. V. Southwell; Flight Lieut. C. Staniland, A.R.Ae.S.I.; Lieut-Commander L. C. Stevens (Assistant Naval Attaché (for Aviation), American Embassy); Mrs. Stevens; Miss A. G. Stewart; Major Oliver Stewart ("Morning Post"); J. Stodart-Kennedy, Esq.; Captain C. G. Sturt, A.F.C., A.C.G.I., B.Sc., A.F.R.Ae.S.; H. Sutton, Esq., M.Sc., F.R.Ae.S.; A. Swan, Esq., B.Sc., A.M.Inst.C.E., A.F.R.Ae.S.; L. A. Sweny, Esq.; Whitney Straight, Esq.

W. A. Tamblin, Esq., A.F.R.Ae.S.; Nigel Tangye, Esq., R.A.F.O., A.R.Ae.S.I.; O. J. Tapper, Esq.; Mrs. Tapper; Lieut.-Colonel E. Tatsumi (Military Attaché, Japanese Embassy); F. M. Thomas, Esq., A.F.R.Ae.S.; F. J. A. Thompson, Esq.; F. O. Thornton, Esq., A.F.R.Ae.S.; F. O. M. R. D. Trewby, A.R.Ae.S.I.; Mrs. Trewby; Major C. C. Turner, A.F.R.Ae.S. ("Daily Telegraph"); T. H. Turner, Esq., M.Sc., A.R.Ae.S.I.; W. L. Tweedie, Esq., A.F.R.Ae.S.; Mrs. Tweedie.

C. F. Uwins, Esq., A.F.R.Ae.S.

Sir Alliott Verdon-Roe, O.B.E., M.I.Ae.E., F.R.Ae.S.; Air Commodore R. H. Verney, O.B.E., A.F.R.Ae.S.; Herr Ludwig Von Blaas (Counsellor, Austrian Legation); Miss B. Voyce.

J. I. Waddington, Esq., B.A., A.F.R.Ae.S.; A. F. Walsh, Esq., B.Sc.; Captain C. E. Ward ("The Bystander"); Mrs. Ward; — Watanabe, Esq.; F. J. Waters, Esq.; Major-General R. A. Wenninger (Air Attaché, German Embassy); Mrs. Wenninger; Flight Lieut. F. Whittle, B.A. (Hons.), A.F.R.Ae.S.; Major C. E. Williams; C. M. Williamson, Esq., C.B.E.; H. E. Wimperis, Esq., C.B., C.B.E., F.R.Ae.S. (President, Royal Aeronautical Society); Mrs. Wimperis; Miss Virginia Wimperis; Lawrence A. Wingfield, Esq., M.C., D.F.C., A.R.Ae.S.I. (Guild of Air Pilots and Air Navigators); Mrs. Wingfield; R. McKinnon Wood, Esq., O.B.E., M.A., F.R.Ae.S.; Mrs. R. McKinnon Wood; Major L. F. E. Wouters, M.C. (Air Attaché, Belgian Embassy); Madame Wouters; Squadron Leader M. E. A. Wright, A.F.C., A.F.R.Ae.S.; H. N. Wylie, Esq., B.Sc., F.R.Ae.S.

R. Zdanowich, Esq., M.A., A.F.R.Ae.S.; H. Zettersten, Esq.; Mrs. H. Zettersten; Miss Anna Zinkeisen.

During the evening there was a display of films showing the research work being carried out by the Royal Aircraft Establishment and the National Physical Laboratory. There were also some films of bird flight. Owing to the large number of members and guests present the films were shown twice.

The President, who spoke on both occasions, said the first film, dealing with the research work, was being shown for the first time in this country. The film dealing with the flight of sea gulls had been shown before, but the second bird film was of special interest in that it showed the flight of humming birds. He had been a little doubtful at one stage whether that film would arrive in time to be shown. It arrived at Southampton in the "Berengaria" which docked late the night before, but with the aid of the Air Ministry it had been possible to make arrangements for the film to be hurried to London in time for it to be shown at the Conversazione. The photographs of the humming bird had been taken at 1,000 photographs per second. Some years ago an attempt was made to photograph humming birds at the Zoological Gardens in London at 250 photographs per second, but that was found to be not nearly fast enough. The photographs which had been taken at 1,000 per second gave an excellent idea of the way the humming bird carried out its operations and the aircraft industry would no doubt agree that it had much to learn from the ingenious way in which the humming bird managed to hover.

The Films.

The first showing of films took place at 9.30 p.m., and the second showing followed at 10.15 p.m. There was a running commentary on the first by Mr. R. P. Alston, B.A., A.F.R.Ae.S., and on the second by Mr. J. E. Serby, B.A.

The first part of the film showed the vertical spinning tunnel in which the model is launched at the end of a long arm. The wind, increasing in velocity upwards, spins the model faster and faster and eventually lifts it off the arm and supports it in a steady spin. The model spins about four times as fast as the full size plane, but a slow motion picture showed the model slowed down to spin at about full-scale speed. When the controls are moved for recovery a white streamer is released from the tail and attention was called to the long time that elapsed in this spin before the rotation ceased and the model fell in a dive. For contrast, a picture was shown of a steeper spin which was produced by raising the tailplane from the mid position to the top of the fuselage. This allowed the rudder to do its work better and thus the recovery was much quicker.

The film then dealt with the seaplane tank. This is 600ft. long and has running down it an electrically driven carriage which is capable of a speed of 40ft. per second. Below the carriage is suspended the model of a seaplane hull, which is thus towed on the surface of the water. The observers ride on the carriage down the tank during which time apparatus on the carriage records the motion of the hull through the water and the forces which the water exerts upon it. The apparatus also supplies the lift which the wings would have given had they been there. The record is made by pens on a rotating drum of paper and in this way much of what happens during take-off can be measured. Before a seaplane is built, a test in the tank enables a design to be checked and altered until it is satisfactory.

Porpoising was then shown, and the manner in which badly designed seaplanes plunge about after the manner of a porpoise was depicted. To examine this, light models are tested in the tank, and these have wings and tails and are weighted correctly. It was shown that as the carriage gathered speed, the pitching motion became worse and worse, and in the words of the commentators, the model shown was behaving in a most undignified manner.

Air flow was next dealt with and the following explanation was given before the film was shown.

A beautiful method has been developed for visualising streamline motion in air. This makes use of the fact that a non-uniform stream of air casts shadows of varying intensity if photographed after passing through a source of heat. If the source of heat is uniform—for instance, a hot wire placed across a two-dimensional stream—beautiful pictures can be made of the growth of vortices when the stream encounters an obstacle. A most amusing and instructive variant of this is to fire heat intermittently into the stream by means of electric sparks. Each spark, said the commentators, is like a swimmer plunging into the stream, leaving a diminishing wake behind. If the sparks were fired from a fixed point at constant intervals, a team of swimmers disappear one after the other down the stream, the wake from each joining up with the head of the swimmer behind. It was further explained that one of the greatest difficulties in aeronautical research is to see what the air is doing, but in this method, which has been developed by Mr. Townend at the National Physical Laboratory, the air flow is made visible in the manner described above.

The method of photography used is due to Schlieren, in which only part of the light is allowed to reach the camera. The first illustration of this effect was using the warm hand as the source of heat, and illumination from the right showed the air rising in convection currents.

Under the title of the single spark gap, the swimmers were shown disappearing endlessly down several stream lines. This stream was diverted by a flat plate.

Then followed a demonstration of a stroboscopic effect in which the swimmers had been frozen into their stream lines by working the camera at the same rate as the firing of the sparks, and it was pointed out that the distance between them was a measure of their speed.

The next part of the film included a diagrammatic representation of the lift and drag increasing as a flat plate was set at a gradually increasing angle to the wind. After a time the lift reaches a maximum and no longer increases; in fact, it decreases, finally shrinking to nothing, leaving dead air behind the plate.

Slow motion of start of flow was shown with the aid of a section of film taken at 2,300 pictures per second. This was recorded by putting a hot wire across a stream which is approaching a flat plate. The asymmetrical flow which appeared first was caused by convection currents. In a slow motion picture of the start of flow round an aerofoil, special attention was drawn to the vortex thrown off from the trailing edge. The streamlines close up initially at the trailing edge although the incidence is high, but later the flow separates from the upper surface.

In the next section of the film, the streamlining of a plate was demonstrated and showed how the drag of a circular disc can be reduced in stages, first by fitting it with a nose, then by adding a short tail and finally by adding a long tail. In its final streamline form, the drag was a fraction of its original value.

The addition of a Townend ring to a radial engine illustrated how the air may be persuaded to flow comparatively smoothly round exposed cylinder heads by surrounding them with a circular ring of aerofoil section.

The stalling of a thick aerofoil was next dealt with and it was shown that the flow separates from the upper surface of the aerofoil at an incidence of about 20 deg. When the Handley-Page slot is brought near to the leading edge, stalling is postponed to a higher incidence.

An illustration was then given of ice accretion and the danger of cold weather flying. It was demonstrated how ice forming at the nose of the aerofoil tends to increase the drag and provoke an earlier stall.

Finally, in this section of the film, the effect of tunnel speed on stalling was demonstrated. It was shown how, as the speed increases, provided the incidence is not too high, the stream lines close up behind the stalled wing, thus illustrating the well-known " scale effect " on maximum lift.

24FT. TUNNEL.

The next film was a description of the construction and method of operation of the 24ft. open jet wind tunnel at the R.A.E. A picture of the outside of the building was given, followed by a plan view of the return circuit of the tunnel. The building is of steel and ferro-concrete construction. The tunnel proper occupies the ground floor and the superstructure above contains the model lift shaft, model erecting bays, offices, etc.

The first operational view was a test of a full-scale wing, mounted on the main balance. The airstream issues from a nozzle 24ft. in diameter, crosses the test space and enters a converging collector. The tunnel fan, 30ft. diameter, driven by a 2,000 h.p. motor, is in the throat of the collector, the balance and observers being housed in a cabin below the jet.

The importance of adequate ventilation of the tunnel is manifest in as much as the exhaust fumes from engines would cause serious inconvenience to the staff. Fresh air is drawn from outside the building to provide ventilation when an engine is being run and exhausting into the jet, the outlet being through a series of holes round the nozzle of the jet, fresh air being continually added to the air circulating in the tunnel. There is a clearance of only half an inch between the tunnel fan and the walls and should the fan blades stretch, a trip is automatically operated which cuts out the main fan motor.

The film then took observers for a trip round the tunnel. Apart from air drawn in for ventilation, the fan drives the same mass of air round and round a closed circuit. After passing the fan, the airstream returns to the nozzle through long corridors with right angle bends. The rotation in the airstream produced by the fan is straightened out by radial vanes and the air is assisted round the corners of the return circuit by cascades of guide vanes or deflectors which, in the words of the commentators, gave the appearance of a cathedral with the great height of 40ft. and illusion of a series of columns. The air flow is expanding on its passage through the return circuit until the nozzle is approached, where it contracts rapidly and emerges finally into the working section as a parallel jet at a speed of 116 m.p.h. The film included a general view of the return circuit. The maximum speed of the fan is 250 r.p.m. The care necessary in the inspection of the tunnel was emphasised and the film included a section showing men going a round of inspection before a test was started. The control panel for operating the fan motor is conveniently situated by the side of the working section. An ingenious automatic device is used for controlling the tunnel speed to any pre-determined value, and indicator lights show when the speed has reached this value. When these lights remain steady balance readings are taken by the observers in the balance cabin.

The film then showed the balance house where the lift and drag are measured. Emphasis was laid on the speed with which the tunnel can be cleared in order that a further experiment may be carried out without waste of time. For this purpose, the test piece and its supporting structure are quickly removable from the balance. Jib cranes are used for transporting the rig from the balance to the erecting shed where modifications can be made while tests on other aeroplane parts are in progress. These operations were shown in detail.

In addition to making full-scale tests on the lower balance, tests can be made with large scale models suspended from an upper balance, and a two-fifths scale model aeroplane was shown in this connection. Part of the roof of the working jet is in the form of a lift which can be raised into the tower in the superstructure. A balance car, complete with balance and suspended model—hanging by wires upside down—is propelled along rails on to the undersurface of the lift. The whole is then lowered through the opening in the jet roof. When the lift is at its lowest limit and just covering the opening, the model is in the centre of the jet. Two balance cars are provided so that while one model is being tested, another model can be rigged on the spare car.

The film concluded with views of the duplicate motor control panel, which is inset in the face of the nozzle above the jet and may be operated from the balance car, and of observers in the balance car operating the lift and drag balances.

Bird Flight.

The remaining films of bird flight were shown without comment. The first part depicted seagulls and pigeons in flight and the latter the flight and hover of humming birds.

The high speed motion pictures of humming birds were taken with the Edgerton stroboscopic light. The Council record their thanks to Professor Edgerton and his associates of the Massachusetts Institute of Technology, Cambridge, Massachusetts, for their generous help in enabling the film to be shown.

Lectures.

Jan. 8th.—F. R. Banks, F.R.Ae.S., "High Duty Aero Engines and Fuels." A Joint Lecture with the Institution of Petroleum Technologists and the Institution of Automobile Engineers.

Jan. 14th.—Dr. C. H. Desch, "Magnesium Alloys."

Jan. 28th.—Dr. N. A. de Bruyne, "Plastic Materials for Aircraft Construction."

Feb. 11th.—Mr. F. W. Meredith, B.A., and Mr. P. A. Cooke, O.B.E., M.C., "The Automatic Pilot."

Feb. 18th.—Mr. A. H. R. Fedden, M.B.E., M.I.A.E., M.S.A.E., F.R.Ae.S., "Trend of Air-Cooled Aero Engines—The Next Five Years."

Feb. 25th.—Mr. N. S. Muir, B.Sc., A.M.I.Mech.E., "Power Measurements in the Air."

March 11th.—Major B. C. Carter, M.I.Mech.E., F.R.Ae.S., A.R.C.Sc., D.I.C., "Airscrew Blade Vibration."

April 8th.—Mr. A. G. Pugsley, M.Sc., A.M.I.Struct.E., "Control Surface and Wing Stability Problems."

April 22nd.—Mr. G. J. Mead, A.F.R.Ae.S., "Power Plant Trends."

April 26th.—Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., Presidential Address, "The Natural Limits to Human Flight."

May 27th.—Dr. Theodor von Kármán, F.I.Ae.S. (Wilbur Wright Lecture), "Turbulence."

Oct. 14th.—Herr R. Hafner, "The Hafner Gyroplane."

Oct. 21st.—F. M. Thomas, Esq., A.F.R.Ae.S., "Practical Airscrew Performance Calculations."

Nov. 4th.—C. N. H. Lock, Esq., M.A., F.R.Ae.S., "Problems of High Speed Flight as Affected by Compressibility."

Nov. 18th.—H. F. Vessey, Esq., B.Sc., A.F.R.Ae.S., "Wing Loading and the Take-off Problem."

Dec. 2nd.—Sqdn. Ldr. H. P. Fraser, A.F.C., B.A., A.F.R.Ae.S., "High Wing Loadings and Some of its Problems from the Pilot's Point of View."

Dec. 16th.—Sqdn. Ldr. G. M. Buxton, "Development of Sailplanes."

Branch Lectures (1937).

Jan. 5th.—Lecture before the Bristol Branch, by Mr. W. C. Devereux, A.F.R.Ae.S., on "Light Alloys."

Jan. 13th.—Lecture before the Southampton Branch, by Squadron Leader R. S. Booth, A.F.C., R.A.F., on "Airships."

Jan. 14th.—Lecture before the Yeovil Branch by a Representative of Mouldrite, Limited, on "Plastics."

Jan. 14th.—Lecture before the Portsmouth Branch, by Mr. I. J. Gerard, M.Sc., A.M.Inst.C.E., A.F.R.Ae.S., on "Stressed Skin Construction."

Jan. 14th.—Lecture before the Manchester Branch, by Mr. R. G. Robertson, B.A., A.M.Inst.C.E., on "Gliding and Soaring."

Jan. 21st.—Lecture before the Portsmouth Branch by a member of Titanine, Limited.

Jan. 21st.—Lecture before Coventry Branch, by Mr. L. A. Sweny, on "Air Route and Aerodrome Control."

Jan. 26th.—Lecture before the Bristol Branch, by Mr. H. B. Howard, F.R.Ae.S., on "Martlesham Methods of Aircraft Testing."

Jan. 28th.—Lecture before the Yeovil Branch, by Mr. N. C. Wilson, on "Press Tool Work."

Jan. 28th.—Lecture before the Portsmouth Branch, by Mr. C. F. Snowden Gamble, on "Commercial Aviation."

Feb. 4th.—Lecture before the Portsmouth Branch, by Mr. M. Langley, A.M.I.N.A., M.I.Ae.E., on "The Use of Plastics in Aircraft Structures."

Feb. 10th.—Lecture before the Southampton Branch by a member of the Staff of Sperry Gyroscope Company, on "Blind Flying."

Feb. 11th.—Lecture before the Yeovil Branch, by Mr. W. C. Devereux, A.F.R.Ae.S., on "High Duty Alloys and their Radiological Testing."

Feb. 11th.—Lecture before the Portsmouth Branch, by Captain F. S. Barnwell, O.B.E., A.F.C., B.Sc., F.R.Ae.S., on "The Design of High Altitude Aircraft."

Feb. 11th.—Lecture before the Manchester Branch, by Mr. J. L. Nayler, M.A., F.R.Ae.S., on "The Problem of Bird Flight and the Aeroplane."

Feb. 10th.—Lecture before the Bristol Branch, by Mr. C. P. Lipscomb, A.F.R.Ae.S., on "The Design of the Empire Flying Boats."

Feb. 18th.—Lecture before the Coventry Branch, by Mr. A. H. Davis, of the National Physical Laboratory, on "Silencing Aircraft."

Feb. 18th.—Lecture before the Portsmouth Branch, by Flight Lieut. H. F. Jenkins, on "Blind Flying."

Feb. 25th.—Lecture before the Yeovil Branch, by Mr. L. H. Pomeroy, M.I.M.E., on "The Reactions of an Automobile Engineer to Aircraft Engines."

March 10th.—Lecture before the Southampton Branch by Mr. F. M. Owner, M.Sc., A.F.R.Ae.S., on "Factors Controlling Aero Engine Development."

March 11th.—Lecture before the Manchester Branch, by Mr. S. M. Parker, on "Hydraulic Services in Aircraft."

March 18th.—Lecture before the Coventry Branch on "Navigation," by Squadron Leader Godsave.

April 8th.—Lecture before the Manchester Branch, by Major T. M. Barlow, M.Sc., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., on "Aircraft Production."

April 14th.—Lecture before the Southampton Branch, by Captain A. Graham Forsyth, on "Modern Airscrew Development."

April 15th.—Lecture before the Coventry Branch, by Mr. S. J. Harley, B.Sc., on "Production and Inspection Methods Applied to Screw Threads."

Sept. 23rd.—Lecture before the Coventry Branch, by Mr. W. C. Devereux, F.R.Ae.S., on "The Future Trend of Light Alloys."

Sept. 30th.—Lecture before the Yeovil Branch, by Mr. E. F. Relf, F.R.S., F.R.Ae.S., on "Scientific Speculations."

Oct. 6th.—Lecture before the Weybridge Branch, by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

October 7th.—Lecture before the Portsmouth Branch, by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

Oct. 14th.—Lecture before the Yeovil Branch, by Mr. F. Entwistle, B.Sc., on "Why is the Weather."

Oct. 19th.—Lecture before the Gloucester and Cheltenham Branch, by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "A Trip into the Stratosphere."

Oct. 19th.—Lecture before the Isle of Wight Branch, by Mr. H. Knowler, A.M.Inst.C.E., A.F.R.Ae.S., on "Flying Boat Development."

Oct. 20th.—Lecture before the Weybridge Branch, by Mr. W. H. Wakinshaw, M.A., Dipl. Educ. Oxon, on "The Meaning of Education."

Oct. 21st.—Lecture before the Coventry Branch, by Mr. S. M. Parker, "The Case for Hydraulic Systems in Aircraft."

Oct. 27th.—Lecture before the Yeovil Branch, by Dr. H. C. H. Townend, F.R.Ae.S., on "Air Flow in Relation to Aeronautics."

Oct. 28th.—Lecture before the Portsmouth Branch, by Captain N. MacMillan, on "Flying and Handling of Seaplanes and Flying Boats."

Nov. 2nd.—Lecture before the Isle of Wight Branch, by H. J. Pollard, Esq., F.R.Ae.S., on "Metal Aircraft Production."

Nov. 3rd.—Lecture before the Weybridge Branch, by Flt. Lieut. P. W. S. Bulman, M.C., A.F.C., F.R.Ae.S.

Nov. 11th.—Lecture before the Portsmouth Branch, by Lieut.-Col. W. Miles, on "The Application of Wireless to Civil Aviation."

Nov. 11th.—Lecture before the Yeovil Branch, by Squadron Leader Hopkins, R.A.F., on "A Survey of Aircraft Armament."

Nov. 12th.—Joint Meeting with the Coventry Branch and the Coventry Engineering Society, by A. Swan, Esq., B.Sc., A.M.Inst.C.E., A.F.R.Ae.S., on "Compression Ignition Aero Engines."

Nov. 16th.—Lecture before the Gloucester and Cheltenham Branch, by a Member of Reynolds Tube Co., Ltd., on "Extruded Sections."

Nov. 16th.—Short papers to be read by Branch members of the Coventry Branch, followed by discussions.

Nov. 16th.—Lecture before the Isle of Wight Branch, by W. Hackett, Esq., on "Manufacture and Manipulation of Steel Tubes."

Nov. 17th.—Lecture before the Weybridge Branch, by W. C. Devereux, Esq., F.R.Ae.S., on "Light Alloy Castings and Stampings for Aeronautical Purposes."

Nov. 25th.—Lecture before the Yeovil Branch, by a Representative of Imperial Airways, on "Air Services."

Nov. 25th.—Lecture before the Portsmouth Branch, by Commander R. R. Graham, A.F.R.Ae.S., R.N., on "Some Aspects of the Flight of Birds."

Nov. 25th.—Lecture before the Coventry Branch, by Dr. R. C. Sutcliffe, on "Clouds and Their Formation, Structure and Associated Flying Conditions."

Nov. 30th.—Lecture before the Bristol Branch, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Bird Flight."

Nov. 30th.—Lecture before the Isle of Wight Branch, by E. Relf, Esq., A.R.C.Sc., F.R.Ae.S., on "Aeronautical Research Methods."

Dec. 1st.—Lecture before the Weybridge Branch, by Mr. H. Roxbee Cox, Ph.D., D.I.C., B.Sc., F.R.Ae.S., on "Large Aeroplanes."

Dec. 9th.—Lecture before the Portsmouth Branch, by Captain F. Entwistle, on "Meteorology and Aviation."

Dec. 9th.—Lecture before the Yeovil Branch, by Squadron Leader F. F. Garraway, O.B.E., on "Organisation and Duties of the Royal Air Force."

Dec. 14th.—Lecture before the Gloucester and Cheltenham Branch, by Mr. P. E. G. Sayer, on "Test Flying."

Dec. 15th.—Lecture before the Weybridge Branch, by J. Donaldson Craig, Esq., on "Anodic Treatment."

Dec. 16th.—Lecture before the Isle of Wight Branch, by G. H. Dowty, Esq., M.I.Ae.E., A.F.R.Ae.S., on "Hydraulic Services in Aircraft."

Dec. 30th.—Lecture before the Yeovil Branch, by Mr. Hugh Bergel, on "Gliding and Soaring."

LECTURES BEFORE PUBLIC SCHOOLS, ETC.

Jan. 6th.—Lecture before the Literary Society, Hatfield Heath, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

Jan. 26th.—Lecture before Hersham Guild, by Captain J. Laurence Pritchard, on "Modern Aeroplanes."

Jan. 29th.—Lecture before Birkenhead School, by Mr. H. A. Mettam, F.R.Ae.S., on "How an Aeroplane is Made and Flies."

Feb. 2nd.—Lecture before Harringay Literary Society, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

Feb. 5th.—Lecture before Kenrick Technical College, by Mr. A. N. Jackson, A.F.R.Ae.S., on "How an Aeroplane is Made and Flies."

Feb. 6th.—Lecture before Eastbourne College, by S. Scott-Hall, A.F.R.Ae.S., on "The Evolution of Aeronautics."

Feb. 9th.—Lecture to King Edward School, Southampton, by Mr. T. Tanner, A.F.R.Ae.S., on "How an Aeroplane Flies."

Feb. 11th.—Lecture before the Hackney Central Library, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

March 1st.—Lecture before Watford Grammar School, by Mr. W. O. Manning, F.R.Ae.S., on "How an Aeroplane is Made and Flies."

March 4th.—Lecture before the City and Guilds' Engineering Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Queer Flying."

March 5th.—Lecture before Balshaw's Grammar School, by Mr. C. L. Old on "How an Aeroplane is Made and Flies."

Oct. 21st.—Lecture before Hendon Central Library, by Mr. H. T. Winter, on "Flight: Yesterday, To-day and To-morrow."

Oct. 20th.—Lecture to the Scientific Society of Loughborough College, by Captain J. L. Pritchard, Hon. F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

Nov. 8th.—Lecture before the Westbury Branch of the British Legion, by Captain F. S. Barnwell, F.R.Ae.S., on "The History of the Aeroplane."

Nov. 22nd.—Lecture before the Halton Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Bird Flight in Relation to Aeronautical Engineering."

Nov. 26th.—Lecture before the Foremen's Mutual Benefit Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Recent Progress in Aircraft."

STUDENTS' SECTION.

The following summarises the activities of the Students' Section for 1936-1937 Session:—

Officers and Committee for 1936-1937.

Chairman: A. F. Walsh, B.Sc.

Hon. Secretary: J. C. Hardman.

Committee: H. Leaderman, L. G. Whitehead, A. K. Hunter, H. Udall, H. G. Grigg, F. T. Meacock, H. E. J. Rochefort, D. A. J. Harben, D. R. Sherwin.

The following meetings were held during the Session:—

1936.

Oct. 1st.—Annual General Meeting.

Oct. 15th.—Inaugural Address: "Recent Developments in Aeronautical Research," Mr. E. F. Relf, A.R.C.Sc., F.R.Ae.S. Chairman: Sir Henry Tizard, C.B., A.F.C., F.R.S., F.R.Ae.S.

Nov. 3rd.—"Technical Aeronautics in Australia," Mr. J. V. Connolly, B.E., A.F.R.Ae.S. Chairman: Mr. S. H. Evans, A.F.R.Ae.S., M.I.Ae.E.

Nov. 20th.—Informal Supper, 8 p.m., at The Cheshire Cheese, Little Essex Street, W.C.2.

Dec. 1st.—"Stressed Skin Construction," Mr. C. Moore, B.Sc., A.F.R.Ae.S. Chairman: Mr. I. J. Gerard, M.Sc., A.M.Inst.C.E., A.F.R.Ae.S.

Dec. 15th.—"Fuels for Aero Engines," Mr. C. H. Barton, M.A. (Joint Meeting with the Graduates' Section of the Institution of Automobile Engineers and the Students' Section of the Institute of Petroleum Technologists.

1937.

Jan. 5th.—"Aircraft Performance Estimation," Mr. C. O. Vernon, Stud.R.Ae.S.I. Chairman: Mr. R. S. Stafford, A.F.R.Ae.S. (Aerodynamics Design Department, Messrs. Handley Page, Limited).

Jan. 19th.—"Critical Speeds of Monoplanes," Mr. J. Hanson, B.Sc. Chairman: Mr. A. G. Pugsley, M.Sc., A.M.I.Struct.E. (Airworthiness Department, Royal Aircraft Establishment).

Feb. 2nd.—Lecture, "Bird Flight in Relation to Aircraft Engineering," by Captain J. Laurence Pritchard, Hon. F.R.Ae.S.

Feb. 16th.—"Production of Light Metal-Clad Aircraft," Mr. I. Waddington, B.A., A.F.R.Ae.S. Chairman: The Lord Sempill, A.F.C., F.R.Ae.S.

March 2nd.—"Flaps," Mr. D. R. Sherwin. Chairman: Mr. W. R. Andrews, A.F.R.Ae.S.

March 16th.—Extended discussion on the paper "Stressed Skin Construction," read by C. Moore.

April 6th.—Debate: "Speed v. Safety in Civil Aircraft Design." Chairman: Captain J. Laurence Pritchard, Hon. F.R.Ae.S.

April 20th.—"Airships and Kite Balloons," Lord Ventry. Chairman: Capt. T. B. Williams.

The following Visits to Works were made:—

1936.

Oct. 17th.—Short Brothers, Limited, Rochester. Pobjoy Airmotors and Aircraft, Limited.

Nov. 7th.—De Havilland Aircraft Company (Engine Department), Stag Lane, Edgware, Middlesex.

Dec. 5th.—Smith's Instruments, Limited, Edgware Road, Cricklewood, N.W.2.

1937.

Jan. 27th.—Ford Motor Works, Dagenham.

Feb. 20th.—The Ratcliffe Tool Co., Ltd., Gorst Road, Park Royal, Great West Road, N.W.10.

March 20th.—The Airscrew Company, Weybridge.

April 24th.—Royal Aircraft Establishment, South Farnborough.

May 22nd.—Gatwick Airport.

June 18th.—Airspeed (1934), Limited, Portsmouth. Saunders Roe, Limited, Isle of Wight.

AWARDS.

At a meeting of Council held on April 12th, 1937, the following Awards were made:—

Society's Gold Medal.—Awarded to the late Senor J. de la Cierva, F.R.Ae.S., for his work on the development of the Autogiro.

Society's Silver Medal.—Awarded to F. W. Meredith, B.A., for his work on the Automatic Pilot.

Society's Silver Medal.—Awarded to P. A. Cooke, O.B.E., M.C., for his work on the Automatic Pilot.

British Gold Medal for Aeronautics.—Awarded to A. Gouge, B.Sc., F.R.Ae.S., for his achievement in the development of Flying Boats.

Simms Gold Medal.—Awarded to Dr. H. Gough, M.B.E., F.R.S., for his paper "New Light on the Strength of Materials Afforded by Modern Physics."

Simms Gold Medal.—Awarded to W. A. Wood for his paper on "New Light on the Strength of Materials Afforded by Modern Physics."

Taylor Gold Medal.—Awarded to Dr. G. P. Douglas, M.C., A.F.R.Ae.S., for his paper on "Cooling Problems with Particular Reference to the Work of the 24ft. R.A.E. Tunnel."

Edward Busk Memorial Prize.—Awarded to Mr. G. H. Dowty, F.R.Ae.S., for his paper on "Retractable Undercarriages."

Pilcher Memorial Prize.—Awarded to H. Leaderman, B.A., B.Sc. (Eng.), for his paper on "The Fundamentals of Boundary Layer Theory with Some Applications to Aircraft."

ELLIOTT MEMORIAL PRIZE.

The Elliott Memorial Prize was awarded to Sergeant/Apprentice W. Beringer, of Halton.

ACKNOWLEDGMENTS.

The Council gratefully acknowledge the following:—

Back numbers of the Journal and other Society publications from Mr. A. G. Taylor (Student), Mr. F. P. Walsh (Associate Fellow), Mrs. J. D. Fullerton (Companion), Miss Etty-Leal (Student) and Mr. R. M. A. Rise (Student).

Slides, photographs, etc., from Mr. H. E. Wimperis, Mr. Leonard Bridgman, Miss Glazebrook, Lieut.-Col. E. E. B. Mackintosh (Director of the Science Museum).

The Council particularly wish to thank Mr. R. L. Carter, Associate, for the gift of an up-to-date lantern to the Library, to replace the one which has outlived its usefulness.

Library books, publications and periodicals from: Dr. F. W. Lanchester, Mr. Henry Hughes, Major Henri Jullerot, Mr. W. O. Manning (Fellow), the Yeovil Branch, Captain Gillman (Associate Fellow) of the Society of British Aircraft Constructors, C. B. Colebrook and C. M. White, Mr. E. Wieser (Associate Fellow), Lieut.-Col. F. A. G. Noel, Mr. S. W. Slaughter (Associate).

ENDOWMENT FUND.

The Council gratefully acknowledge the gift of five guineas to the Endowment Fund from Messrs. Gale and Polden, Limited; one guinea each from Mr. A. J. Henington (Associate Member) (for the seventh year in succession), Mr. J. W. C. Logan (Associate Member) (for the sixth year in succession); and 8s. from Squadron Leader G. P. Tzannetakis (Associate Fellow); 5s. from a Student who wishes to remain anonymous; and 10s. from Pilot Sgt. J. V. Saunders (Associate Member).

GARDEN PARTY.

The Society held its annual Garden Party on Sunday, May 9th, 1937, at the Great West Aerodrome, near Hayes, the use of which was kindly given to the Society for the day by Mr. C. R. Fairey, M.B.E., F.R.Ae.S., a former President. Despite the bad weather, which caused a curtailment of the flying programme, the attendance of members and their friends was the largest since the function was first inaugurated. Nearly 4,000 members and their friends were present, including many distinguished guests from Overseas who were attending the Coronation.

The whole of the arrangements at the aerodrome were once again under the control of Mr. Fairey and his staff, and the Council wish to record their thanks for the most excellent organisation which allowed so much of the programme to be carried out despite the weather conditions. The Council wish particularly to record their thanks to Mr. C. R. Fairey for the constant and generous help which he has always given to make the Garden Party a success in every possible way. They wish, too, to record their thanks and appreciation of the help given by Flight Lieutenant C. S. Staniland, who was responsible for the flying arrangements and those of the static display. Flight Lieutenant C. S. Staniland was called upon to modify the programme at short notice and it was due to his work and careful organisation and the willing help of so many of Mr. Fairey's staff that such an interesting display was finally given.

The following programme was carried out during the afternoon:—

2.30—3.10 p.m.—Reception by the President, Mr. H. E. Wimperis, Mrs. Wimperis and Members of Council.
3.15 p.m.—Captain J. B. Wilson. B.A. Double Eagle.
3.21 p.m.—Flying Officer J. K. Quill. Vickers Wellesley.
3.28 p.m.—Flying Officer J. K. Quill. Miles Straight, Villiers-Maya.
3.34 p.m.—Mr. Brian Allan. Tipsy S.2.
3.42 p.m.—Flight Lieutenant P. E. G. Sayer. Gloucester Gladiator.
3.52 p.m.—Mynheer T.E. Slot. Schelde-Musch.
4.00 p.m.—Mr. E. G. Hordern. Hordern-Richmond Autoplane.
4.15 p.m.—Mr. J. D. Kirwan. Aeronca Jap.
Mr. R. Kronfeld. Kronfeld Single-Seater.
4.35 p.m.—Flying Officer Clouston. Hafner Gyroplane.
Mr. R. A. C. Brie. Cierva C.30.
5.00 p.m.—Tea interval.
5.30 p.m.—Mr. Field Richards. Porterfield Monoplane.
5.40 p.m.—Mr. E. G. Hordern. Heston Phœnix.
5.50 p.m.—Flight Lieut. C. S. Staniland. Fairey P.4/34.
6.00 p.m.—Mr. R. G. J. Nash and Mr. R. O. Shuttleworth each flew a Bleriot machine round the aerodrome and Mr. R. Kronfeld taxied the Ground Trainer.
6.10 p.m.—Bell's Asbestos Company. Fire Prevention Demonstration.

Dr. Whitehurst was in attendance during the afternoon as the Medical Officer on the Aerodrome.

Arrangements had been made for the Westland Lysander and the Bristol Blenheim to attend, but owing to the weather conditions neither machine was permitted to make the journey to the aerodrome.

The following machines, in addition to those of private owners arriving by air, were on the aerodrome, including those which gave demonstrations during the afternoon:—

Aeronca Jap. (Aircraft Exchange and Mart, Ltd.)
Gipsy Major Cadet. (Airwork, Ltd.)
B.A. Eagle. (British Aircraft Manufacturing Co., Ltd.)
B.A. Double Eagle. (British Aircraft Manufacturing Co., Ltd.)
B.A. Swallow (two machines). (British Aircraft Manufacturing Co., Ltd.)
Bleriot Monoplane, 1909. (International Horseless Carriage Corporation.)
Schelde Musch. (Mynheer T.E. Slot.)
Cierva Autogiro. (The Cierva Autogiro Co.)
Cygnet Minor. (C.W. Aircraft, Ltd.)
De Havilland Tiger Moth, Hornet Moth, Dragon Rapide. (De Havilland Aircraft Co.)
Douglas D.C.3. (K.L.M. Airlines.)
Fairey P.4/34. (The Fairey Aviation Co., Ltd.)
Fairey Swordfish. (The Fairey Aviation Co., Ltd.)
Hafner Gyroplane A.R. III, Mk. II. (A.R. III Construction.)
Heston Phœnix. (The Heston Aircraft Co., Ltd.)
Hordern Richmond Autoplane. (Courtesy of Duke of Richmond.)
Kronfeld De Luxe Drone. (Kronfeld, Ltd.)
Kronfeld Ground Trainer. (Kronfeld, Ltd.)
Lockheed Electra. (British Airways, Ltd.)
Miles Whitney Straight. (Phillips and Powis Aircraft, Ltd.)
Miles Maya. (Villiers Hay Development, Ltd.)
De Luxe Monospar S.T. 25. (General Aircraft, Ltd.)
Monospar Ambulance. (General Aircraft, Ltd.)

Parnall Heck. (Aircraft Exchange and Mart, Ltd.)
Percival Vega Gull. (Germ Oil Co.)
Sopwith Camel, 1917. (International Horseless Carriage Corporation.)
Stinson Reliant. (Brian Allen Aviation, Ltd.)
Tipsy S.2. (Tipsy Light Aircraft—Brian Allen Aviation, Ltd.)
Vickers Wellesley. (Vickers Aviation, Ltd.)

The Council wish to record their thanks to all those pilots, firms and others who so willingly helped with the display of the above aircraft.

During the display engineers in the recording van of the Outside Broadcasts Department of the British Broadcasting Corporation were reproducing the running commentary, later transmitted on the National wavelength after the news bulletin the same evening.

A Static Display was given in one of the hangars, and the Council wish to thank the following for their assistance in making the display of such interest during the afternoon:—

Aircraft materials, shown by Messrs. Accles and Pollock, Ltd.; hydraulic system for aircraft, shown by Aircraft Components, Ltd.; aircraft brakes and operating gear, shown by Bendix, Ltd.; aircraft materials, shown by Aero Research, Ltd.; hydraulic equipment for aircraft, shown by Automotive Products, Ltd.; Bristol engines shown by the Bristol Aeroplane Co., Ltd.; aero mixture indicating unit, and temperature indicator, shown by the Cambridge Instrument Co., Ltd.; Ecta electrically conducting tail equipment, shown by the Dunlop Rubber Co., Ltd.; pneumatic brakes and machine gun control, shown by the Dunlop Rubber Company, Ltd.; carburettor master control scheme, shown by H. M. Hobson (Aircraft and Motor) Components, Ltd.; Harley Landing Lamp, Type V. 50 I.C., Dalton Aircraft Navigational Computer, Mark VII, and Holmes Aircraft Repeater Compass, shown by Smith's Aircraft Instruments, Ltd.; Husun P.4 L. Aperiodic Compass, shown by Henry Hughes and Sons, Ltd.; aircraft instruments, shown by the Sperry Gyroscope Company, Ltd.; model aircraft, shown by the Model Transport Company, Ltd.; the first wireless patent granted in Great Britain, the Coherer, Aircraft Radio Installation (1920) and (1937), shown by the Marconi Wireless Telegraph Co., Ltd.; wheel and brake equipment, shown by the Palmer Tyre Co., Ltd.; Rolls-Royce Kestrel VI, shown by Rolls-Royce, Ltd.; the Napier Halford Dagger air-cooled in-line engine, shown by D. Napier and Son, Ltd.; lubrication equipment, shown by Tecalemit, Ltd.; load-carrying properties of lubricants, shown by Silvertown Lubricants, Ltd.; the deviator or stabilised gyroscope, automatic directional control apparatus, portable invisible light detector, shown by P.B. Deviator Control, Ltd.; De Havilland controllable pitch airscrew, shown by De Havilland Aircraft Co., Ltd.; service type altigraph, shown by Short and Mason, Ltd.; and instruments shown by W. T. Avery and Co., Ltd.

The Council would like to thank Mr. W. Courtenay, M.M., A.R.Ae.S.I., for his help during the afternoon. Mr. Courtenay gave a broadcast description of the events as they were taking place; the Automobile Association, and particularly Mr. Tapper, for their organisation of the car and aeroplane park and preparation of a map showing how to arrive at the aerodrome; and to Mr. L. A. Rumbold and his organisation in the aircraft park.

The Council would like to place on record their thanks for the help given by the Air Council granting permission for certain service machines to be present at the display and for their permission for the Central Band of H.M. Royal Air Force to play during the afternoon.

OBITUARIES.

Major B. F. S. BADEN-POWELL, *Honorary Fellow*, 1860-1937.

By the death of Major B. F. S. Baden-Powell, at the age of 77, on October 3rd, the Society lost its oldest member. Major Baden-Powell was elected a member of the Society at a meeting of the Council held on April 21st, 1880. Two of the members of Council present were James Glaisher and P. H. Wenham. The membership of the Society at that time was exactly 80, and included such well known pioneers as James Glaisher, Otto Lilienthal, Thomas Moy, John Stringfellow and P. H. Wenham. With the death of Major Baden-Powell there has been severed a link with a remarkable period of aviation pioneering. To Major Baden-Powell the Society owed its very existence, for he kept it alive by his enthusiasm and energy during a period when its tiny flame of existence was flickering in the winds of scepticism and opposition.

In 1892 he was elected to the Council and from then onwards delivered many papers before the Society and took part in the discussions of many others. From 1892 to 1896 the membership of the Society steadily dwindled, and at the Council meeting held in November, 1896, Major Baden-Powell agreed to act as Honorary Secretary. The balance of the Society's assets over its debts was £5 5s. 0d. The new Honorary Secretary widened the interest in the Society, and the Journal, which had lapsed, was issued quarterly under his editorship. In March, 1897, Major Baden-Powell reported a balance of £15 and a membership of 39, including four honorary members. An extract from the Council Minutes of the time reads: "The Society did not possess sufficient funds to provide a suitable quarterly journal without outside support. However, the Honorary Secretary (Major B. F. S. Baden-Powell) suggested issuing the Journal entirely at his own expense and risk."

In 1899 Major Baden-Powell left England to take part in the South African War, and it was stated in the Council Minutes that, as Honorary Secretary, he had virtually re-established the Society. In July, 1900, he was elected President of the Society, a post he held for seven years. In 1908 he was elected a Vice-President.

Major Baden-Powell was one of the first to experiment with man-lifting kites, and, as stated in the Journal (April, 1897) "the first well authenticated occasion on which a man was raised by a kite was on June 27th, 1894, when Captain Baden-Powell, Scots Guards, conducted some experiments at Pirbright Camp." Previously he had been a leading spirit in military ballooning. During the Boer War his kites were successfully used for reconnaissance, photography and wireless. It was in 1881 he made his first balloon ascent, and in 1884 he owned his own balloon. In 1898 he read his exhaustive paper on Kites in Theory and Practice.

Always a close student of the possibilities of heavier-than-air flight, in March, 1904, he read a paper on Experiments with Aerial Screw Propellers, after having carried out 350 tests on various types of airscrews. In the Journal for July, 1904, Major Baden-Powell described at length his experiments with gliders at the Crystal Palace, with a view to building a power-driven aeroplane. The experiments were carried out with Mr. J. T. C. Moore-Brabazon.

On October 8th, 1908, Major Baden-Powell flew with Wilbur Wright, being the second Englishman to fly. The first was Mr. Griffith Brewer, who flew on the same day with Mr. Wilbur Wright, shortly before Major Baden-Powell.

Major Baden-Powell joined the Society before the majority of its present members were born. He not only saved it from extinction, but when he laid down the reins of office after fifteen years of continuous work as a member of Council, Honorary Secretary and President, he saw it well on its way towards the position it now holds as the most authoritative body of its kind in the world.

At the Council meeting held in April, 1930, the following resolution was unanimously passed:—

"The Council in recording in their Minutes that on April 21st, 1930, Major B. F. S. Baden-Powell, a former President of the Society and for many years a member of Council, had been a member of the Society for fifty years, wish to extend their heartiest good wishes to him for the future, and to congratulate him upon the completion of a record unique in the Society's history."

We are not concerned here with Major Baden-Powell's career outside aviation, only to say that he served on the Nile in 1884 and 1885, in the South African War 1899-1900, and the Great War 1914-1918. With his death, however, the world has lost one of its most lovable personalities, many have lost a close friend, and the Society has lost a member to whom it must ever owe the deepest debt of gratitude.

Herbert Charles William Brewer, *Associate Fellow*, 1904-1937.

Herbert Charles William Brewer was killed at the early age of 33 in a railway accident at Swanley Junction on June 27th. The son of the late Rev. H. P. Brewer, he was educated at Lancing College, and Queen's College, Cambridge, where he took an honours degree in engineering. In 1927 he joined the technical staff of the Fairey Aviation Company and showed outstanding ability. He was responsible for a great deal of the design of the Battle, and became an authority on stressed skin construction. Later, at Stockport, he became chief technical officer on the production of the Battle. He took every opportunity of flying on flying trials to obtain a practical insight of the machine with which he had been concerned.

A man who was personally immensely popular and able, the death of H. C. W. Brewer is a serious loss of one who would have risen high in his profession. He was elected an Associate Fellow of the Society in 1935.

Reginald Joseph Mitchell, *Fellow*, 1895-1937.

The death of Reginald Joseph Mitchell on June 11th, 1937, meant to British aviation the loss of one of its most brilliant designers.

Born at Stoke-on-Trent, he served his apprenticeship with Kerr, Stuart and Co., Ltd., of which he became assistant engineer. In 1916 he joined the Supermarine Aviation Works, Ltd., and became chief engineer and designer in 1920. In 1922 he helped to modify the A.D. flying boat which won the Schneider Trophy for Great Britain, and was concerned in the designs of an amphibian for the Martlesham competition, machines for various foreign governments and the Air Ministry.

In 1924 came Mitchell's first outstanding success with the S.4 which made a world's speed record of 226.76 miles per hour. In 1927 he produced the S.5 which won the Schneider Trophy at Venice, and in 1929 the S.6 which won the trophy at Southampton, and in 1931 the S.6b which finally won the trophy outright for Great Britain, achievements without parallel in aircraft design. The S.6b made a speed record of 407½ m.p.h. following the last Schneider Trophy race, and for his work Mr. Mitchell was made a C.B.E.

Despite the intense concentration during those years necessary to produce the fastest seaplanes in the world, Mr. Mitchell was able to design the flying boats Southampton, Scapa and Stranraer, which have been widely ordered by the Royal Air Force. He also designed the Seagull for coastal patrol for the Royal Australian Air Force and the Walrus amphibian for the Fleet Air Arm. A year before his death he produced the Spitfire, one of the fastest single-seater fighters in the service.

In the brief twenty-one years he was in aviation Mr. Mitchell became recognised as one of the leading designers of the world, and had he lived there is little doubt he would have continued to stand out head and shoulders among most of his contemporaries. He was a member of Council and was elected to the Society in 1918, and awarded its Silver Medal in 1927.

The following is an appreciation of Mr. Mitchell by one who worked in close association with him:—

"I feel impelled as one who has worked for R.J. to express a few words of appreciation. All who have worked for him or under him have had a rare opportunity to see how careful consideration and genius can be perfectly applied. His was a quiet, subtle not obvious genius, and has often been mistaken for luck. 'Lucky Mitchell' he was called sometimes, but there wasn't really much luck. His intuitive capacity for grasping the essentials, getting to the point and staying there, was one of his great characteristics. A corollary to this was his uncanny ability to detect errors in involved estimations or calculations by the application of simple common sense. His mind was difficult to follow when on a problem, partly because he was a man of few words and said nothing unless there was something worth saying, but mainly because most people's minds tend to rush on and over obstacles, whereas he would stick at a snag day after day until every aspect of every solution was clear. Then instead of a snap decision he would make a considered compromise.

"He once said in connection with aeroplane design: 'Don't do to-day what you can put off until to-morrow,' for premature decisions are often what have killed promising designs. R.J. mistrusted complex theory and involved calculations because in spite of their impressiveness they so easily lead one up the garden. He would say that unless an estimation can be done in a few minutes, it is not worth doing, or that practically any result can be obtained with sufficient accuracy by an approximation. R.J. brought a completely open mind to bear on each new design. He didn't hamper himself by former ideas and decisions on new work. Every possible scheme would be investigated. In his opinion experience was more important than theory, and he would ask the advice and study the experience of many people, and not only of those in closest touch with him. Suggestions from any member of his staff were always welcomed, and he never turned down a suggestion because he had turned it down once before. Even proposals to which he reacted unfavourably would not be dismissed without thorough investigation. After gathering so many and varied opinions, his genius asserted itself by his ability to digest them and grasp the essential truth. His designs were thus brilliant compromises, showing little of the development of a single idea such as may be seen in other cases. This freedom from set ideas enabled him to produce outstanding designs of widely varying type, such as Southampton II, the Schneider Trophy seaplanes and the Spitfire, which in their times were or are the best of their kind in the world."

Brigadier-General Sir CAPEL HOLDEN, *Fellow*, 1856-1937.

Brigadier Sir Capel Holden died on March 30th, 1937. The eldest son of the Rev. Dr. H. A. Holden, he joined the R.A. in 1875. He was a brilliant engineer and the inventor of many instruments and apparatus for artillery and electrical science. He was elected a Fellow of the Royal Society in 1895, became Vice-Chairman of the Royal Aero Club, Vice-President of the Institution of Electrical Engineers and of the Royal Society of Arts. He was Chairman of the Royal Automobile Club in 1905, served on the board of the National Physical Laboratory from 1907 to 1911, read the James Forrest lecture before the Institution of Civil Engineers in 1908 and was President of the Radio Society of Great Britain in 1927.

Sir Capel Holden was elected to the Society in 1913.

Captain the Right Honourable FREDERICK EDWARD GUEST, *Companion*.
1875-1937.

The Right Honourable Frederick Edward Guest, P.C., C.B.E., D.S.O., M.P., was born in June, 1875, the third son of the first Baron Wimborne.

He joined the East Surrey Regiment in 1894 and was appointed to the 1st Life Guards, 1897, serving against the Sudanese 1899-1900 and in the South African War 1901-2. During the Great War he was A.D.C. to Sir John French and from France went to German East Africa. In all his campaigns he was mentioned in despatches, and in Africa was awarded the D.S.O.

Elected to Parliament in 1910 in 1921 he was appointed Secretary of State for Air, but was defeated in the General Election of the following year. In 1923 he re-entered Parliament of which he remained a member until his death.

In 1930 he flew in the King's Cup Race and following the death of Sir Sefton Brancker he became Deputy Master of the Guild of Air Pilots and Air Navigators, of which later he became Master. From 1926 to 1931 he commanded No. 600 (City of London) Squadron of the Auxiliary Air Force and on his retirement was made an Honorary Air Commodore.

The Right Hon. Frederick Guest took a keen and lively interest in aviation and was a constant advocate for it both in and out of Parliament. He had that personality, gracious and charming, which drew friends to him in all ranks of life, and his work for aviation has yet to be estimated at its true value. A great sportsman, a thoroughly sound friend, and an entertaining companion, the world of aviation is the poorer for its loss.

JUAN DE LA CIERVA, *Fellow*, 1895-1936.

Juan de la Cierva was killed in an accident to a K.L.M. Douglas machine on December 9th, 1936. It was the irony of fate that the man who had spent so many years designing a type of aircraft which would be safe under all conditions of flight, should himself be killed in a type of aeroplane which he was endeavouring to supersede.

Juan de la Cierva was born at Murcia, in Spain, on September 21st, 1895. An accident in a fixed wing type of aeroplane led him to consider if it were possible to develop an entirely new type of aircraft which would land slowly and not be subject to disaster when the engine failed.

For some years he worked on the problem of the revolving wing and in 1924 photographs and descriptions of his autogiro began to be published in the British press. In 1925 he brought one of his machines to England and Mr. Wimperis, the Director of Scientific Research, with a clarity of vision which has been so abundantly justified, arranged for further development work to be carried out on the new type. On October 19th, 1925, the Cierva autogiro was flown at Farnborough. Under the guidance of Senor de la Cierva's genius the relatively crude machine of the day was slowly but steadily developed until there came, shortly before his death, the final stage, the jumping autogiro.

Three times Senor de la Cierva lectured before the Royal Aeronautical Society on his invention, as it was improved stage by stage. Each time it was to record a new step forward. The story of the development of his outstanding invention is told in the pages of the JOURNAL.

Senor de la Cierva was a man who may rightly be said to be a genius, from his infinite capacity for taking pains. He took no step forward without the greatest care and investigation and allowed no one to test the practical result of his theories until he had first done so himself. He was a man of courage and vision, one who broke brilliantly away from the path of tradition, and one who will have left an indelible impress of his outstanding abilities on aviation progress.

Elected to the Society in 1932, he was awarded its Silver Medal, and posthumously the highest honour the Society could bestow, its Gold Medal, as a recognition of his remarkable achievements.

R. A. Tarleton, 1936.

R. A. Tarleton was killed in an aeroplane crash on November 16th, 1936, while making a cross-country flight on an inspection visit as Locomotive Superintendent of the Jodhpur Railway. He was piloting the machine himself and subsequent investigation made it clear that he must have been taken ill in the air and lost control.

Mr. Tarleton was a skilled pilot, and one of the early observers in the Royal Flying Corps. He was a keen member of the Jodhpur Flying Club and made constant use of the aeroplane to carry out his duties. He did much in India to encourage aviation and his loss there was severely felt.

George Harold Barraclough, *Associate Member*, 1894-1937.

George Harold Barraclough was born in December, 1894, and at the time of his death was managing director of Barracloughs (Engineers), Ltd. Educated at Bradford Grammar School and at the City of Bradford Technical College, after a short experience in the Bradford Electricity Department he obtained his flying certificate in 1917. He had in 1913 shown his early interest in aviation by building various types of model aeroplanes, carrying out experiments on aerofoil sections, and designing a model three-cylinder rotary engine. His bent lay on the engine side and in later years he was responsible for a number of patents on sparking plugs, petrol gauges, etc. He was elected an Associate Member in 1924.

James John Brand, *Associate Member*, 1904-1937.

James John Brand was born in March, 1904, and trained as a carpenter-rigger at the Royal Air Force Apprentices' School, Cranwell, from 1920 to 1923. From 1924 to 1929 he was employed on aircraft construction work at the Royal Air Force depots at Hinaidi and Karachi, and as N.C.O. in charge of No. 10, B Squadron, 1931-1933. He showed considerable ability and qualified as metal rigger and fitter, Grade I, and finally Flight Sergeant.

Albert Henry Lawrence, *Associate Member*, 1910-1937.

Albert Henry Lawrence was born in October, 1910, and entered the Royal Air Force at the Halton Technical School in 1926, from which he passed out in 1929 as aircraftsman, first class. From 1930-1932 he was senior fitter of W./S. 13 (A.C.) Squadron, carrying out complete overhauls of Jaguar aero engines, Napier Lions and Rolls-Royce Kestrels and Condors. He was appointed senior fitter at the aero engine Jaguar shop at Abu Sueir, Egypt, where he showed exceptional ability in his work. He was elected an Associate Member in 1936.

John Edmund Roe, *Student*, 1916-1937.

John Edmund Roe became a student of the Society in June, 1936. He took his senior matriculation from the Department of Education, Province of Alberta, Canada, and on his arrival in England he received a post in the drawing office at Messrs. Phillips and Powis Aircraft, Ltd., of Reading. He joined the Royal Air Force Reserve and was killed while on flying practice. J. E. Roe had every prospect of an excellent career in aviation, and his death at such an early age is a great loss.

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On the Corrections to be Applied to Silver-Disk Pyrheliometry, C. G. Abbot.

(The) Phenological Report, 1936, Royal Meteorological Society.

Scientific Notes, India Meteorological Department

Normal Monthly Percentage Frequencies of Surface and Upper Winds up to 3 Km. at Allahabad, Begumpet, Delhi, Sambalpur, Sandoway, Silchar and Victoria Point (Volume VII, No. 72), S. P. Venkiteshwaran.

Daily Variations of Temperature and Pressure at Different Levels over Agra Associated with Passage of Western Disturbances (Volume VII, No. 73).

Synoptic and Aeronautical Meteorology, Horace Robert Byers.

Temperature and Relative Humidity in the Atmosphere over Lower Egypt, Meteorological Office Professional Notes No. 75, William D. Flower.

PROCEEDINGS OF OTHER INSTITUTIONS

Institution of Mechanical Engineers, Proceedings of the, Volume 133, April-November, 1936.

(The) Institution of Mechanical Engineers, Proceedings of, Volume 134, November-December, 1936.

Institution of Mechanical Engineers, Proceedings of the, Volume 135, January, 1937.

Institution of Naval Architects, Transactions of, Volume LXXIX.

(The) Journal of the Institute of Metals, No. 1, 1937, Institute of Metals.

Institute of Metals, Journal of the, Volume LIX.

Chartered Institute of Patent Agents, Transactions of the, Volume LIV, Session 1935-1936, Institute of Chartered Patent Agents.

Institute of Plastics Industry, Transactions of the, Volume VI, January, 1937, No. 11.

Institution of Professional Civil Servants, Annual Report of Council for the Year 1936.

REVIEWS

Ice Accretion on Aircraft.

By G. C. Simpson, K.C.B., F.R.S. Air Ministry M.O. 420b. H.M.S.O., 1937. 3d. net.

The prevention of ice accretion on aircraft has been one of considerable study in the past few years, and Sir George Simpson, in this small monograph, has very excellently summed up the position in the form of Notes for Pilots on the subject.

The physical explanation of the formation of ice, often at temperatures which are unexpected, is very clearly given. It is followed by a description of the weather conditions and temperature at which ice forms on the wings. Temperatures between 32°F. and 23°F. accounted for more than half the occasions of ice accretion in observed cases. The occurrence of ice falls off rapidly at temperatures below 18°F. and practically ceases at 0°F. In Great Britain, January and February are the most dangerous months, followed by December.

In his general rules for avoiding the dangers of ice accretion, Sir George Simpson very cogently observes that unless ice accretion is observed in flight there is one and only one method of escaping its dangers, and that is to get out of the ice-forming layer at the first possible moment. He explains when it is better to try to climb or to come down to a lower altitude, pointing out that in general if the reserve power of the aircraft is great escape is best attempted upwards, unless it is definitely known that good conditions exist below.

The meteorological conditions leading to ice accretion are now fairly well known and warnings are issued by the Meteorological Office of the heights and areas where such formation is likely to take place. The author is not concerned with the physical methods of preventing ice forming on the wings, but he so clearly states the conditions and what the pilot should do that a copy of these notes should be the property of every pilot. One cannot often get an insurance premium for threepence which will give such a good return for the money invested.

Zeppelin.

By Capt. Ernst A. Lehmann. Published by Longman's at 15s.

Such was the impression that the name and personality of Dr. Eckener had made upon the general public of the world that all reports on the flights of the "Graf Zeppelin" invariably gave him the credit for its wondrous series of world flights. Although a great deal of the credit must indeed go to Dr. Eckener, his position on the airship during flight was in an advisory capacity, the actual handling and navigating of the airship being in the hands of the ship's officers, usually under the command of Captain Lehmann.

With the projected increase of the airship fleet and the launching of the "Hindenburg," Dr. Eckener became more occupied with the business and development side of the undertaking, so that Lehmann's light was just beginning to peep out from behind the shadow of his chief, and his worth and ability recognised by the world at large, when, with the irony of fate and fame, he was taken from us, muttering as he staggered away mortally injured from the blazing wreck of the "Hindenburg" (as Commander Rosendahl tells us in his beautifully written preface to Captain Lehmann's posthumous book "Zeppelin"): "I don't understand it; I don't understand it."

The book referred to is a fascinating one, not only to the person interested in air transport, but to the layman as well, as it is written in simple non-technical language and reveals an activity in peace and war of which few people, outside those specially interested, had any idea.

The book opens with a description, by means of the radiograms which passed between the airship and the ground, of the memorable occasion when, owing to one of the periodical revolutions in South America, the " Graf Zeppelin " remained cruising in the air for five days while the revolution was overcome. With this as an introduction to whet our contemporary appetites, the author cleverly reverts to describing his experiences in the early days of the development of commercial airship transport in Germany before the war, leading on naturally to his experiences in command of various airships during the war both on the eastern and western fronts. His recounting of the long series of raids, engagements and reconnaissance flights is not confined merely to those in which he himself took part, but include those of many other naval and military airships. He also does not gloss over their losses, which were enormous considering the size of the airship section. Yet the Germans were never short of 'ships; rather was it that they were short of personnel to man them, for whereas it took two years for a crew to become efficient, the Zeppelin factories at one period in the war were building one new airship complete in the astoundingly short period of fourteen days, incredible as this may seem to be, judging from our own standards of time in the production of rigid airships. Production had to be slowed down because there were insufficient crews trained.

Captain Lehmann has little or no time for the pressure type of airship and he rather belittles our efforts in the anti-submarine campaign, whilst making large claims for his own side. This is understandable, however.

The battle of Jutland is described from the point of view of the airships which took part in it and lent such undoubted aid to the German high command, and indicates the advantage the Germans obtained from their better air reconnaissance. Interesting and illuminating on the value of airships as eyes of the German fleet in that battle is the summary of the report to the British Admiralty quoted by Admiral Moffat to the U.S.A. parliament:—

> " From the results it is plain that the confidence of the Germany Navy in their airships is more than justified. To the credit of the airships it may be said that they saved the German fleet in the battle of the Skager Rak just as they saved the German cruisers during an attack on Yarmouth and were instrumental in sinking the ' Nottingham ' and ' Falmouth ' off the English coast." The description of the battle would have been much enhanced had it been accompanied by a chart.

From this the author rather inconsequently divagates to a description of old Count Zeppelin's early efforts and struggles. One point of interest to Englishmen, and to Australians in particular, is the reference to the improvements made in the elevators as a result of researches made with Hargrave kites.

The farm girl crying out angrily: " Let me hang out my wash," as the helpless early Zeppelin floated down on her, reminded me somewhat of an occasion when I was flying an " S.S." airship very low at Driffield and an old washerwoman stood in front of us waving her outstretched arms as if trying to head off a straying cow.

Von Schiller's description of his 'ship's experience in a thunderstorm is a miniature classic, but must have been a terrifying experience.

That marvellous flight of the L-59 from Yamboli in Bulgaria to Khartoum and back is, in my opinion, a foreshadowing of the use to which airships should be put in future wars, operated, of course, by neutral crews, *i.e.*, the rapid evacuation of the more seriously wounded and the transport of medical supplies to the seat of war.

In the description of the " Graf Zeppelin's " round-the-world flight I again felt the need of maps and charts. To my mind, the flight non-stop across the greatest land mass in the world (Europe and Asia), a great deal of which has never been surveyed, with mountains actually much higher than given on such maps as are available, while others are not marked at all, was one of the outstanding flights of all time and immeasurably superior to those carried out about that time by aeroplanes engaged on the same undertaking though not over the same route. 7,000 miles non-stop in 100 hours mostly over uncharted grund will take some beating. Her record from the 1st August to the 4th September, 1929, will, I should say, remain as a record for all time, viz., 31,000 miles in 450 hours flying time. It would be interesting to know how many hours' flying time these German airship pilots have put in; it must be something colossal.

Lehmann gives short paragraphs on the losses of our own R-101, and of the American " Akron " and " Macon," but has little to add to our knowledge of them. The impression one receives from these paragraphs is to use them as a demonstration of the superior strength and design of the German built 'ships. His few remarks on the reason for breaking up of R-100 show him to be acquainted with the facts.

The last chapter in the book makes sad reading. It is a description of the disaster by Commander Rosendahl (who was an eye witness) in collaboration with Mr. Leonhard Adelt who, with his wife, was one of the survivors. From the photographs in this part it seems impossible that anyone should have got away from the 'ship alive and yet it is a fact that but one-third of all on board perished in the crash or as the result of injuries received in it. One is left repeating Lehmann's words: " I don't understand it; I don't understand it."

Speaking generally on the book, the translation is excellent on the whole, though there were some words with which I am unacquainted, such as " go-wheel," " interne," " Echolot," " Referent," " aviso." One or two other terms rather jarred, such as " combat fliers " for " fighters " and " dove " for " dived," but these are minor blemishes.

I suppose it is too much to expect an index in a book of this description, but it would be very useful if one should want to turn up any episode, as the book is not written in chronological sequence.

G. Otto: " Entwurf und Berechnung von Flugzeugen, Band I, Tragfluegel " (Design and Calculation of Aeroplanes, Vol. I, Wing). 88 p., 78 figs. and 3 plans. By C. J. E. Volkmann. Nachf. E. Wette, Berlin, Charlottenburg, 1937. Price RM. 3.50.

This book purports to treat an example of the calculation of a cantilever wing (similar to the upper wing of Mignet's " Flying Flea "). But, fortunately, the book is by no means limited to that. It is a valuable supplement to the author's " Konstruktionselemente fuer den Flugzeugbau " (see this Journal, Vol. 1937, p. 337).

The author starts with discussing the choice of a wing section, the reduction of wind tunnel data, explains the proper calculation of the loads occurring under different flying conditions according to the latest German load assumptions, and follows with the usual elementary stress calculation for a normal cantilever two-spar wing system. The air loads acting on the ribs are especially considered. The shape of spars and ribs in wooden and metal construction is discussed, and another chapter is devoted to the dimensioning of such parts in metal necessitating the use of Wagner's formulæ and torsional shear calculating methods of Prandtl for obtaining the strain in wings under torsional loads.

Apart from certain incoherencies the book seems to be instructive and well written for people acquainted with the fundamentals it is based upon. But like

most books of this purely illustrative kind, the student in aeronautics is confronted with formulæ and mathematical prescriptions without sufficient warning as to the assumptions and limitations implied. Obviously, the author has done his best to deal in a clear way with so much in so small a frame. A critical slide rule expert may object to some calculations done to such a rather unnecessary and even misleading degree of accuracy unobtainable by means of normal slide rules. But this does not affect the value of the book.

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

JANUARY, 1937

The New Year.

The President (Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S.) and Council wish all members a happy and prosperous 1937.

Conversazione, January 12th, 1937.

Members are reminded of the Conversazione on January 12th, 1937, the 71st anniversary of the foundation of the Society. The Conversazione will be held at the Science Museum, South Kensington, S.W.7, by kind permission of the Director, Lieut.-Colonel E. E. B. Mackintosh. The function on January 12th next and in future will be separated from the Wilbur Wright Memorial Lecture, which will be held as usual during the last week in May. The Council hope that members will make a note of the date and will make every effort to attend. By kind permission of the Air Ministry a special air research film will be shown for the first time in this country, and a film of bird flight. Application for tickets (5/- each, including buffet) should be made as early as possible.

Special General Meeting, January 21st, 1937.

Members are reminded of the Special General Meeting to be held in the Offices of the Society on Thursday, January 21st, at 6.30 p.m. The agenda has been sent to all voting members and it is hoped as many members as possible will attend the meeting.

Special Joint Lecture.

A joint lecture with the Institution of Petroleum Technologists will be given on Friday, January 8th, 1937, by Mr. F. R. Banks on "Some Problems of Modern High Duty Aero Engines and Their Fuels." The lecture will be given in the Lecture Hall of the Royal Society of Arts at **5.30** p.m.

List of Members.

With the January issue of the Journal is circulated the List of Members for 1937. In future the List of Members will be published with the January issue of the Journal.

Meeting of Council.

A meeting of the Council was held in the Offices of the Society on Tuesday, December 8th, 1936, when the following members were present:—

Mr. H. E. Wimperis (President) in the chair; Mr. H. Roxbee Cox, Mr. A. Gouge, Professor F. T. Hill, Professor G. T. R. Hill, Major D. H. Kennedy (Honorary Treasurer), Captain A. G. Lamplugh, Mr. W. O. Manning, Mr. F. Handley Page (Vice-President), Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Mr. O. E. Simmonds, Mr. L. A. Wingfield (Solicitor).

Among the business transacted was the following:—Conversazione of January 12th, 1937; Report of the Finance Committee; Report of the Grading Committee; Interim Report of the Development Committee; suggested composite photograph of members of the Society; appointment of representatives on a Permanent Joint Committee with the Society of British Aircraft Constructors in connection with

the Scholarship Scheme; Report of the Referees on the R.38 Memorial Prize entry; appointment of the President to represent the Society at the Semi-Centennial Celebrations of the Engineering Institute of Canada in June, 1937.

Election of Members.

The following members were elected at the meeting of Council held on December 8th, 1936:—

Fellow.—Albert Percival Rowe.

Associate Fellows.—William Gee Bickley, Carl Robert Chronander, William Edgar Noel Clark, Harold Basset Collins, George William Jones, Edgar George Vardy, Leonard William Warner, Patrocle John Yangos.

Associate Members.—Ernest Dudley Johnson, John Percival Pryer.

Students.—Frank Allsopp, Stanley Mark Angel, Arthur Kenneth Baker, Harry Charles Netterville Barron, Edward Noel Brailsford, Edmund John Cardell, Jack Appleton Channer, Roy Derek Cullum, John Dubbury, Jas. Ferguson Gibbon, Leslie William Ivey, John Leslie Longden, John Marshall McAlonan, Edwin Arthur Nash, Arthur Sydney Robins, Joseph Leonard John Rowland, James Walter Scott, John Cyril Knowles Shipp, Thomas Ernest John Solby, Leslie Sykes, Howard Buckley Wilkinson, Ronald Bartlett Wilkinson.

Companions.—Ernest Folley, Erach Godivala, Herbert Kimber, Miss Alice Grainger Stewart.

Society of British Aircraft Constructors' Scholarships.

The Society of British Aircraft Constructors are offering a minimum of four scholarships a year of varying value up to a maximum of £100 each per annum. The scholarships are designed for the assistance of young men, between the ages of 16 and 18, who are unable, for financial reasons, to take up a course of education fitting them to become aircraft engineers.

Each scholarship will be for four years, contingent upon satisfactory work being done by the holder and will be tenable with certain selected firms in the industry. The award of the scholarships will be made by a joint committee of the Society of British Aircraft Constructors and the Royal Aeronautical Society. The Royal Aeronautical Society will be responsible for the general administrative and other arrangements. The Selection Committee will normally make awards in March or April each year, and for 1937 application for the necessary form and particulars should be sent to the Secretary of the Royal Aeronautical Society, 7, Albemarle Street, W.1, before February 28th, 1937.

Members' Subscriptions.

Members are reminded that their subscriptions were due on January 1st, 1937. The Council hope that every member will make every effort to pay his subscription as early as possible. The rates are:—

	Home.	Abroad.
	£ s. d.	£ s. d.
Fellow	4 4 0	3 3 0
Member	4 4 0	3 3 0
Associate Fellow	3 3 0	2 2 0
Associate Member	3 3 0	2 2 0
Associate	*2 2 0	*2 2 0
Student	1 1 0	1 1 0
Companion	2 2 0	2 2 0
Founder Member	2 2 0	2 2 0

*£1 1s. 0d. without Journal.

Engineering Institute of Canada.

The Engineering Institute of Canada, with which the branches of the Society in Montreal and Ottawa are affiliated, is holding its semi-centennial celebrations on June 15th, 16th and 17th, 1937, at Montreal. At the meeting a series of technical papers dealing with the main branches of engineering will be read of international as well as Canadian note and interest. Luncheon meetings will be arranged at which addresses on more general subjects will be given by prominent speakers, and many official delegates will be present from engineering societies in other countries.

Visits will be arranged to engineering works and other points of interest and special arrangements will be made for the entertainment of ladies. On Friday, June 18th, the meetings will be continued at Ottawa, the seat of the Dominion Government, where a programme of interest will be arranged.

The Engineering Institute has branches in Toronto, Hamilton and other important centres and arrangements will be made to receive delegates and others who visit these centres.

The Council have appointed Mr. H. E. Wimperis, C.B., C.B.E., F.R.Ae.S. (President), to represent the Society. It is particularly requested that any member of the Society who is visiting Canada on that date will get in touch with the Secretary as soon as possible.

The Canadian Pacific Railway Company are making special arrangements for those who wish to visit Montreal at the time of the 50th Anniversary Celebrations of the Engineering Institute of Canada. The s.s. "Duchess of York" will leave Liverpool on Friday, June 4th, and return on Friday, July 2nd, 1937. A programme of sightseeing in Canada has been arranged. Full particulars may be obtained direct from the C.P.R. Offices in Trafalgar Square, London, S.W.1.

The Cunard White Star, Limited, also have special round-trip rates, and are willing to arrange post-Conference tours in Canada and/or the United States for individuals or parties. Full particulars may be obtained from the Company at 26/7, Cockspur Street, London, S.W.1.

Fifth International Congress for Applied Mechanics (1938).

The American Committee, to whom has been delegated responsibility for organising the Fifth International Congress for Applied Mechanics by the International Committee at its meeting at Cambridge University, England, in July, 1934, announces that the Fifth Congress will meet in Cambridge, Massachusetts, U.S.A., September 12-16, 1938, at Harvard University and the Massachusetts Institute of Technology. As in the past, this Congress is to be a meeting of persons working in the field of Applied Mechanics before whom reports of recent work may be presented for discussion.

The programme will cover three main divisions of Applied Mechanics as follows:—

I. Structures, Elasticity, Plasticity, Fatigue, Strength Theory, Crystal Structure.

II. Hydro and Aerodynamics, Gasdynamics, Hydraulics, Meteorology, Water Waves, Heat Transfer.

III. Dynamics of Solids, Vibration and Sound, Friction and Lubrication, Wear and Seizure.

Following the meeting at Cambridge, Mass., it is expected that arrangements will be made to visit Washington (National Bureau of Standards) and Langley Field (National Advisory Committee for Aeronautics). Dormitory and boarding facilities will be made available by Harvard University.

Inquiries should be addressed to the

Fifth International Congress for Applied Mechanics,
Massachusetts Institute of Technology,
Cambridge, Mass., U.S.A.

Additions to the Library.

Concrete in Aerodrome Construction. The Cement and Concrete Association.

Proceedings of the Institution of Mechanical Engineers, Volume 132, 1936.

Small Four-Stroke Aero Engines. C. F. Caunter.

Experimentelle Untersuchungen uber Flugelschwingungen. H. L. Studer.

Copper in Chemical Plant. Copper Development Association.

Air Navigation Act, 1936.

The Nautical Almanac, 1937.

The Nautical Almanac (Abridged for the Use of Seamen for the Year 1937).

Regulations for Admission to the Royal Air Force College, Cranwell.

International Sanitary Convention for Aerial Navigation, The Hague, April 12th, 1933.

Air Photography (Organisation and Training). Air Publication 1354.

Admiralty Manual of the Sperry Gyro Compass, 1931.

Physical Constants of Pure Metals. National Physical Laboratory, 1936.

The Air Force Act, 1936.

Résumé of Commercial Information, Series 7, No. 3, September-October, 1936.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1691. Comparison of Drag of Trousered and Retractable Undercarriages, by R. Jones, A. H. Bell and A. F. Brown.

No. 1709. Experiments on a Heinkel He. 70 Aeroplane in the Compressed Air Tunnel, by R. Jones and E. Smyth.

No. 1711. A Successive Approximation Process for Solving Simultaneous Linear Equations, by J. Morris.

No. 1712. Full-Scale and Model Porpoising Tests of the Singapore IIc, by W. G. A. Perring and J. L. Hutchinson.

No. 1713. Full-Scale Tests of Slots and Flaps on a Heinkel He. 64, with Special Reference to Landing, by J. E. Serby and H. B. Squire.

Forthcoming Events.

Jan. 5th.—Lecture before the Bristol Branch, by Mr. W. C. Devereux, A.F.R.Ae.S., on "Light Alloys."

Jan. 5th.—Lecture before the Students' Section in the Library at 7, Albemarle Street, at 7 p.m. Mr. C. O. Vernon on "Aircraft Performance Estimation."

Jan. 6th.—Lecture before the Literary Society, Hatfield Heath, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

Jan. 8th.—Joint Lecture with the Institution of Petroleum Technologists and the Institution of Automobile Engineers, at the Royal Society of Arts, 18, John Street, W.C.2, at 5.30 p.m. Mr. F. R. Banks, F.R.Ae.S., on "High Duty Aero Engines and Fuels."

Jan. 12th.—Conversazione at the Science Museum, South Kensington, 8.30 p.m. to midnight. Tickets 5/- (including buffet). Two films will be shown.

Jan. 13th.—Lecture before the Southampton Branch, by Squadron Leader R. S. Booth, A.F.C., R.A.F., on "Airships."

Jan. 14th.—Lecture before the Society at the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m. Dr. C. H. Desch, F.R.S., on "Magnesium Alloys."

Jan. 14th.—Lecture before the Yeovil Branch by a Representative of Mouldrite, Limited, on "Plastics."

Jan. 19th.—Council Meeting in the Offices of the Society at 5.30 p.m.

Jan. 19th.—Lecture before the Students' Section in the Library of the Society at 7 p.m., on "Critical Speeds of Monoplanes," by Mr. J. Hanson, B.Sc.

Jan. 21st.—Special General Meeting in the Library of the Society at 6.30 p.m. Voting members only.

Jan. 21st.—Lecture before the Portsmouth Branch by a member of Titanine, Limited.

Jan. 21st.—Lecture before Coventry Branch, by Mr. L. A. Sweny, on "Air Route and Aerodrome Control."

Jan. 26th.—Lecture before Hersham Guild, by Captain J. Laurence Pritchard, on "Modern Aeroplanes."

Jan. 26th.—Lecture before the Bristol Branch, by Mr. H. B. Howard, F.R.Ae.S., on "Martlesham Methods of Aircraft Testing."

Jan. 27th.—Visit to the Ford Motor Works, Dagenham, by the Students' Section, 2.45 p.m.

Jan. 28th.—Lecture before the Yeovil Branch, by Mr. N. C. Wilson, on "Press Tool Work."

Jan. 28th.—Lecture before the Society in the Lecture Theatre of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m. Dr. N. A. de Bruyne, on "Plastic Materials for Aircraft Construction."

Jan. 29th.—Lecture before Birkenhead School, by Mr. H. A. Mettam, F.R.Ae.S., on "How an Aeroplane is Made and Flies."

Feb. 2nd.—Lecture before the Students' Section in the Library at 7, Albemarle Street, at 7 p.m., by Captain E. W. Percival, M.I.Ae.E.

Feb. 2nd.—Lecture before Harringay Literary Society, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

Feb. 2nd.—Lecture before the Technical School, Rochester, by Captain J. Laurence Pritchard, on "A Trip into the Stratosphere."

Feb. 5th.—Lecture before Kenrick Technical College, by Mr. A. N. Jackson, A.F.R.Ae.S., on "How an Aeroplane is Made and Flies."

Feb. 6th.—Lecture before Eastbourne College, by S. Scott-Hall, A.F.R.Ae.S., on "The Evolution of Aeronautics."

Feb. 10th.—Lecture before the Southampton Branch by a member of the Staff of Sperry Gyroscope Company, on "Blind Flying."

Feb. 11th.—Lecture before the Society at the Lecture Theatre of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m. Mr. F. W. Meredith, B.A., and Mr. P. A. Cooke, O.B.E., M.C., on "The Automatic Pilot."

Feb. 11th.—Lecture before the Hackney Central Library, by Mr. H. T. Winter, on "A Trip into the Stratosphere."

Feb. 11th.—Lecture before the Yeovil Branch, by Mr. W. C. Devereux, A.F.R.Ae.S., on "High Duty Alloys and Their Radiological Testing."

J. LAURENCE PRITCHARD, *Secretary and Editor*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

FEBRUARY, 1937

New Year's Honours.

K.C.B.

Henry Thomas Tizard, Esq., C.B., A.F.C., F.R.S. (Fellow of the Society).

C.B.

Arthur Henry Hall, Esq., C.B.E. (Fellow of the Society).

A.F.C.

Flt. Lieut. Cyril Frank Uwins (Associate Fellow of the Society).

Meeting of Council.

A Meeting of the Council was held in the offices of the Society on January 19th, 1937.

Present.—Mr. H. E. Wimperis (President) in the Chair; Major J. S. Buchanan, Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. Gouge, Professor F. T. Hill, Professor G. T. R. Hill, Mr. W. O. Manning, Mr. F. Handley Page (Vice-President), Dr. N. A. V. Piercy, Mr. O. E. Simmonds, Mr. L. A. Wingfield (Solicitor).

Among the business discussed was the following:—Report of the Finance Committee; Report of the Grading Committee; Representation on the Joint Committee on Materials and their Testing; Segrave Trophy Award; appointment of a representative on a General Committee to consider arrangements for a General Discussion on Lubrication and Lubricants; suggested award of the Gold Medal of the Society.

Nominations for Council.

Attention is drawn to Rules 68-85 regulating the constitution of the Council, and in particular to Rules 79 and 81, which read as follows:—

> RULE 79.—One half of the Council (excluding the President and the Immediate Past-President if a member of Council) shall retire annually. The members who shall retire shall be those longest in office, except as provided in Rule 85. Retiring members of Council who have served two terms in succession (four years) shall not be eligible for re-election until the next annual election, when they will be eligible.
>
> RULE 81.—Nominations of candidates for election to the Council must be received by the Secretary not less than twenty-one days before the Annual General Meeting, with an intimation in writing by the candidates that they are willing to serve. Nominations must be signed by one supporter and two seconders, who must each be entitled to vote in the R.Ae.S.I.

Under Rule 105 the Annual General Meeting is held at some convenient date before the end of March of each year, so that nominations must be received during the first week in March, and preferably by March 1st at the latest.

Graduates.

At a Special General Meeting held in the Offices of the Society on Thursday, January 21st, 1937, new rules were approved for a Graduate grade in the Society.

Under these rules Graduates shall be persons not under 21 years of age and not more than 26 years of age (except in such cases as the Council may determine), who have passed the Associate Fellowship or Associate Membership Examination, or an existing examination, and have received or are receiving training fitting them for the profession of aeronautics.

The rules come into force immediately and the pertinent changes in the rules will be given in detail in the March JOURNAL in the Annual Report of the Council.

Election of Members.

The following recommendations of the Grading Committee were approved by the Council at a meeting held on January 19th, 1937.

Fellows: M. J. B. Davy, G. H. Dowty, D. McL. Ferrier, R. A. Watson Watt.

Associate Fellows: J. C. Brooke, J. Dobson, W. J. Goodey, C. Hayes, Miss E. M. G. MacGill, J. G. Nagle, J. A. Vigil, C. Carr Young.

Associate Members: W. A. Conley, R. Hollingworth.

Associates: D. A. R. Clark, H. E. Francis-Stead, K. R. Imeson.

Students: H. Barnes, J. B. Bucher, A. L. Fermor, M. D. Gibson, V. C. Gunn, C. Horsfield, S. Hyde, J. J. Kaye, D. R. Newman, J. B. Sheldon, M. H. Sheward, R. Smelt, E. Swingler, B. E. Treganowan, G. E. L. Walker, J. M. T. Woodcock.

Companions: C. D. Stanley, Whitney W. Straight.

Endowment Fund.

The Council gratefully acknowledge for the seventh year in succession a donation of £1 1s. 0d. from Mr. A. J. Henington, Associate Member. Mr. Henington has consistently contributed to the Endowment Fund since the general appeal was first made.

The Council also gratefully acknowledge the gift of 4/- to the Endowment Fund from a Student member who wishes to remain anonymous.

Associate Fellowship and Associate Membership Examinations.

The next examinations will be held at 7, Albemarle Street, W.1, in May, 1937. Entry forms, obtainable from the Secretary, should be sent in with entrance fees not later than March 31st. Entries received after that date will not be considered valid.

The following candidates were successful in the December, 1936, examinations:

Associate Fellowship Examination.

K. W. Hetzel ...	...	Applied Mathematics (1st place tied). Theory of Internal Combustion Engines (1st place). Aircraft Materials.
F. J. Horn ...	...	Pure Mathematics.
D. I. Husk ...	...	Applied Mathematics (1st Place tied). Theory of Internal Combustion Engines. Aircraft Materials (1st place).
F. H. M. Lloyd	...	Applied Mathematics (1st place tied). Design (Aircraft).
R. S. Lloyd ...	...	Applied Mathematics. Aircraft Materials.

D. Milne	Design (Aircraft).
	Aerodynamics (1st place).
H. G. S. Peacock ...	Applied Mathematics.
R. Towers	Applied Mathematics.
	Theory of Internal Combustion Engines.
	Design (Aero Engines).
A. P. West	Aerodynamics.
M. B. Williams ...	Pure Mathematics.
	Aircraft Materials.

Associate Membership Examination.

S. J. G. French ...	Applied Mathematics (1st place).
	Theory of Internal Combustion Engines.
	Aircraft Materials (1st place.)
T. A. Gawade ...	Applied Mathematics.
	Theory of Internal Combustion Engines (1st place).
	Aircraft Materials.
R. G. S. Hogarth ...	Applied Mathematics.
	Theory of Internal Combustion Engines.
	Aircraft Materials.
C. F. Mervyn-Jones ...	Applied Mathematics.
	Theory of Internal Combustion Engines.
	Aircraft Materials.
W. J. M. Moss ...	Applied Mathematics.
	Theory of Internal Combustion Engines.
	Aircraft Materials.
C. G. Saunders ...	Theory of Internal Combustion Engines.
W. W. Sayers ...	Applied Mathematics.

Joint Lecture.

A Joint Meeting for a symposium on "Research in Relation to the Motor Vehicle" with the Institution of Automobile Engineers and other Institutions, will be held on Tuesday, March 2nd, at 7 p.m., in the Hall of the Royal Geographical Society, Kensington, when the following papers will be read and discussed:—

"Some Factors Affecting Design," by Mr. C. G. Williams, Director of Research, I.A.E.

"Fuels and Lubricants," by Dr. F. H. Garner, Anglo-American Oil Company.

"Materials with special reference to Steel," by Dr. T. Swinden, United Steel Companies, Limited.

The meeting will commence at 7 p.m. and adjourn at 8.15 p.m. for refreshments after which a discussion on the papers will be held.

Advance copies of the papers may be obtained from the Secretary of the Society at 1s. 6d. for the three.

Exhibition of Airports and Airways.

An exhibition of photographs, models and diagrams of airports and airways will be held by the Royal Institute of British Architects from February 19th, at the headquarters of the Institute at 66, Portland Place, W.1. Members of the Society are particularly invited to attend. The central feature of the exhibition will be a twelve feet wide model of an illuminated and fully equipped modern airport which has been designed for the exhibition by a group of architect-specialists.

Leverhulme Research Fellowships, 1937.

Applications are invited for Fellowships and Grants in aid of research. The Fellowships are intended primarily to provide for senior workers a period of freedom from routine duties, during which they may undertake or complete researches which are being delayed through the pressure of other work. Applicants must be British-born and normally resident in the United Kingdom. Forms of application may be obtained from the Secretary, Leverhulme Research Fellowships, Union House, St. Martins-le-Grand, E.C.1. Applications must be received on or before 1st March, 1937. Awards will be announced in July, and the Fellowships or Grants will date from September 1st, 1937.

The Autogiro.

The attention of the Editor has been called to the fact that the word "Autogiro" is a Registered Trade Mark of the Cierva Autogiro Co., Ltd., and can only properly be used in connection with actual goods the property of The Cierva Autogiro Co., Ltd., and not in a descriptive sense of defining a type of aircraft.

Additions to the Library.

The Air Annual of the British Empire, 1937. Edited by Squadron Leader C. G. Burge.

Airplane and Engine Maintenance, Daniel J. Brimm and H. Edward Boggess.

Proceedings of the Institution of Mechanical Engineers. Volume 133, 1936.

A Simple Study of Flight. J. D. Haddon.

Inspection of Aircraft after Overhaul ("B" Licence). S. J. Norton. (3rd Edition).

Engineering Aerodynamics (Revised Edition). W. S. Diehl.

Diesel Engine Design (Fourth Edition). H. F. P. Purday.

Publications Scientifiques et Techniques du Ministere de L'Air:—

No. 96. Nouvelles Méthodes de Mesures Mécaniques, par Andre Labarthe.

No. 97. Contribution a L'Étude de L'Allumage et de la Combustion Dans les Moteurs a Explosion, par Tchang Te-Lou.

Konstrukstionselemente Für Den Flugzeugbau, von Dipl. Ing. Gerhard Otto Vereinigung fur Luftfahrtforschung, Jahrbuch, 1935.

Handbuch der Luftfahrt, Jahrgang, 1936.

A Handbook of Home Grown Timbers, Forest Products Research. Department of Scientific and Industrial Research.

De Havilland Controllable-Pitch Airscrews (Hamilton Patents).

Gipsy Six Aero Engines, Series I and II.

British Standard Glossary of Aeronautical Terms, British Standards Institution.

The Measurement of Upper Winds by Means of Pilot Balloons. Meteorological Office.

Cloud Forms, Definitions and Photographs. Meteorological Office.

Averages of Bright Sunshine for the British Isles for Periods Ending 1935. Meteorological Office.

Averages of Temperature for the British Isles for Periods Ending 1935. Meteorological Office.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1701. The Effect of Central Cutaway in Split Flaps on the Trim of a Low Wing Monoplane, by D. W. Bottle, C. Callen and K. W. Kirkby.

No. 1706. Tests of Six Aerofoil Sections at Various Reynolds Numbers in the Compressed Air Tunnel, by E. F. Relf, R. Jones and A. H. Bell.

No. 1707. Trailing Edge Flaps in Relation to Take-Off and Landing of Landplanes, by S. G. Gates.

No. 1708. Effect of Surface Roughness on Characteristics of Aerofoils N.A.C.A. 0012 and R.A.F. 34, by R. Jones and D. H. Williams.

No. 1714. Interim Report on Systematic Model Research in Free Spins: Low Wing Monoplanes, by R. H. Francis.

No. 1716. Oscillations of Elastic Blades and Wings in an Airstream, by W. J. Duncan, A. R. Collar and H. M. Lyon.

No. 1717. Tests of Aerofoils R.A.F. 69 and R.A.F. 89 with and without Split Flaps, in the Compressed Air Tunnel, by D. H. Williams, A. F. Brown and E. Smyth.

No. 1718. The Use of Dynamically Similar Models for Determining the Porpoising Characteristics of Seaplanes, by L. P. Coombes, W. G. A. Perring and L. Johnston.

No. 1719. Full Scale Tests of the Hendy Heck (with an Appendix giving Pilot's Notes), by A. E. Woodward Nutt and P. A. Hufton.

No. 1722. The Effect of a Reduction of Aileron Torsional Stiffness on the Flutter of a Model Wing, by V. M. Falkner, W. P. Jones and C. Scrupton.

Reports of the National Advisory Committee for Aeronautics:—

No. 558. Turbulence Factors of N.A.C.A. Wind Tunnels as Determined by Sphere Tests. Robert C. Platt.

No. 559. The Forces and Moments Acting on Parts of the XN2Y-1 Airplane During Spins. N. F. Scudder.

No. 560. A Simplified Application of the Method of Operators to the Calculation of Disturbed Motions of an Airplane. Robert T. Jones.

No. 563. Calculated and Measured Pressure Distributions over the Midspan Section of the N.A.C.A. 4412 Airfoil. Robert M. Pinkerton.

No. 564. Tests of a Wing-Nacelle-Propeller Combination at Several Pitch Settings up to 42°. Ray Windler.

No. 565. Measurements of Fuel Distribution Within Sprays for Fuel-Injection Engines. Dana W. Lee.

No. 566. Ground-Handling Forces on a 1/40-Scale Model of the U.S. Airship "Akron." Abe Silverstein and B. G. Gulick.

No. 569. Wing-Nacelle-Propeller Interference for Wings of Various Spans: Force and Pressure-Distribution Tests. Russell G. Robinson and William H. Herrnstein, jnr.

No. 576. Aircraft Accidents. Methods of Analysis, Report Prepared by Committee on Aircraft Accidents.

Technical Notes of the National Advisory Committee for Aeronautics:—

No. 572. Performance of Air-Cooled Engine Cylinders Using Blower Cooling. Oscar W. Schey and Herman H. Ellerbrock, jnr.

No. 573. Carbon-Monoxide Indicators for Aircraft, by S. H. J. Womack and J. B. Peterson.

No. 574. Tank Tests of Models of Flying Boat Hulls having Longitudinal Steps. John M. Allison and Kenneth E. Ward.

No. 575. Estimation of Moments of Inertia of Airplanes from Design Data. H. W. Kirschbaum.

No. 576. Tank Tests of a Model of the Hull of the Navy PB-1 Flying Boat—N.A.C.A. Model 52. John M. Allison.

No. 577. Friction of Compression-Ignition Engines. Charles S. Moore and John H. Collins, jnr.

No. 578. Full-Scale Wind-Tunnel and Flight Tests of a Fairchild 22 Airplane Equipped with a Fowler Flap. C. H. Dearborn and H. A. Soulé.

No. 579. Charts for Calculating the Performance of Airplanes having Constant-Speed Propellers. Roland J. White and Victor J. Martin.

No. 581. A Study of Autogiro Rotor-Blade Oscillations in the Plane of the Rotor Disk. John B. Wheatley.

Forthcoming Events.

February 2nd.—Lecture before Rochester Technical School, by Captain J. Laurence Pritchard on " A Trip into the Stratosphere."

February 2nd.—Lecture before the Students' Section, in the Library at 7, Albemarle Street at 7 p.m., by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on " Bird Flight in Relation to Aircraft Engineering." Mr. J. L. Nayler, F.R.Ae.S., in the chair.

February 2nd.—Lecture before Harringay Literary Society, by Mr. H. T. Winter, on " A Trip into the Stratosphere."

February 5th.—Lecture before Kenrick Technical College, by Mr. A. N. Jackson, A.F.R.Ae.S., on " How an Aeroplane is Made and Flies."

February 6th.—Lecture before Eastbourne College, by S. Scott-Hall, A.F.R.Ae.S., on " The Evolution of Aeronautics."

February 9th.—Meeting of Council in the offices of the Society at 5.30 p.m.

February 9th.—Lecture to King Edward School, Southampton, by Mr. T. Tanner, A.F.R.Ae.S., on " How an Aeroplane Flies."

February 10th.—Lecture before the Southampton Branch, by a member of the staff of the Sperry Gyroscope Company, on " Blind Flying."

February 11th.—Lecture before the Society in the Lecture Theatre of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m., Mr. F. W. Meredith, B.A., and Mr. P. A. Cooke, O.B.E., M.C., on " Aeroplane Stability and the Automatic Pilot."

February 11th.—Lecture before the Hackney Central Library, by Mr. H. T. Winter, on " A Trip into the Stratosphere."

February 11th.—Lecture before the Yeovil Branch, by Mr. W. C. Devereux, A.F.R.Ae.S., on " High Duty Alloys and their Radiological Testing."

February 11th.—Lecture before the Portsmouth Branch, by Captain F. S. Barnwell, O.B.E., A.F.C., B.Sc., F.R.Ae.S., on " The Design of High Altitude Aircraft."

February 11th.—Lecture before the Manchester Branch, by Mr. J. L. Nayler, M.A., F.R.Ae.S., on " The Problem of Bird Flight and the Aeroplane."

February 14th.—Lecture before the Portsmouth Branch, by Mr. M. Langley, M.I.Ae.E., A.M.I.N.A., on "The Use of Plastics in Aircraft Structures."

February 16th.—Lecture before the Students' Section, in the Library at 7, Albemarle Street, W.1, at 7 p.m., Mr. I. Waddington, B.A., A.F.R.Ae.S., on " Production of Light Metal-Clad Aircraft." The Lord Sempill, F.R.Ae.S. in the Chair.

February 16th.—Lecture before the Bristol Branch, by Mr. C. P. Lipscomb, A.F.R.Ae.S., on " The Design of the Empire Flying Boats."

February 18th.—Lecture before the Coventry Branch, by Mr. A. H. Davis, of the National Physical Laboratory, on " Silencing Aircraft."

February 18th.—Lecture before the Portsmouth Branch, by Flight-Lieut. H. F. Jenkins, on " Blind Flying."

February 18th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m., Mr. A. H. R. Fedden on " Possible Lay-Outs for Air-Cooled Engines."

February 20th.—Visit of the Students' Section to the works of The Ratcliffe Tool Company, Limited, Gorst Road, Park Royal, Great West Road, N.W.10, at 2.30 p.m.

February 25th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m., Mr. N. S. Muir, B.Sc., A.M.I.Mech.E., on "Power Measurements in the Air."

February 25th.—Lecture before the Yeovil Branch, by Mr. L. H. Pomeroy, M.I.M.E., on "The Reactions of an Automobile Engineer to Aircraft Engines."

March 2nd.—Joint Meeting with the Institution of Automobile Engineers and other Institutions, on Research in relation to the Motor Vehicle," at 7 p.m., in the hall of the Royal Geographical Society, South Kensington, S.W.7.

March 2nd.—Lecture before the Students' Section in the Library, at 7, Albemarle Street, W.1, at 7 p.m., Mr. D. R. Sherwin on "Flaps." Mr. W. R. Andrews, A.F.R.Ae.S., in the Chair.

March 4th.—Lecture before the City and Guilds Engineering Society by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Queer Flying."

March 5th.—Lecture before Balshaws Grammar School, by Mr. C. L. Old, on "How an Aeroplane is Made and Flies."

March 10th.—Lecture before the Southampton Branch by Mr. F. M. Owner, M.Sc., A.F.R.Ae.S., on "Factors Controlling Aero Engine Development."

March 11th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m., Major B. C. Carter, M.I.Mech.E., F.R.Ae.S., A.R.C.Sc., D.I.C., on "Airscrew Blade Vibration."

March 11th.—Lecture before the Manchester Branch, by Mr. S. M. Parker, on "Hydraulic Services in Aircraft."

March 16th.—Discussion by the Students' Section in the Library, at 7, Albemarle Street, London, W.1, at 7 p.m., on the paper by Mr. C. Moore, on "Stressed Skin Construction." (Read before the Students' Section on December 1st, 1936).

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

MARCH, 1937

Annual General Meeting.

Notice is hereby given that a Special General Meeting of the Royal Aeronautical Society, with which is incorporated the Institution of Aeronautical Engineers, will be held on Wednesday, March 31st, 1937, at 6.30 p.m., at the Offices of the Society, 7, Albemarle Street, London, W.1.

AGENDA.

1. To receive and deliberate upon the Report of the Council on the state of the Society, and the Balance Sheets of Aerial Science, Limited, and Aeronautical Trusts, Limited, as printed in the *Journal of the Royal Aeronautical Society*, with which is incorporated the Institution of Aeronautical Engineers, for March, 1937.
2. To receive the report of the Scrutineers of the names of those elected to fill the vacancies on the Council for the years 1937-1939.
3. To elect the Auditors for the ensuing year for Aerial Science, Limited, and Aeronautical Trusts, Limited.
4. To consider the alteration of Rule 35A to read as follows:—
   Graduates shall be persons not under 21 years of age, and not more than 28 years of age.
5. To consider the alteration of Rule 57 (Appendix—Subscriptions):—
   Section 1. Line 6.

	Home.	Abroad.	
Graduates ...	£2 2s. od.	£2 2s. od.	(aged 21-25).
	£2 12s. 6d.	£2 12s. 6d.	(aged 26-28).

   Section 2, first two lines to read as follows:—
   Entrance Fee on election of a Fellow ... £5 5s. od.
   ,, ,, ,, Member ... £5 5s. od.
   Section 3, the first four lines to read as follows:—
   The Transfer Fee from Associate Fellow to Fellow or Member shall be £3 3s. od.
   The Transfer Fee from Associate Member to Member or Fellow shall be £3 3s. od.
6. To consider any other business.

By Order of the Council,

J. LAURENCE PRITCHARD, *Secretary*.

Light refreshments will be served during the meeting.

Election of Council.

Attention is drawn to Rules 68-85 regulating the constitution of the Council, and in particular to Rules 79 and 81, which read as follows:—

RULE 79.—One half of the Council (excluding the President and the Immediate Past-President if a Member of Council) shall retire annually. The members who shall retire shall be those longest in office, except as provided in Rule 85. Retiring members of Council who have served two terms in succession (four years) shall not be eligible for re-election until the next annual election, when they will be eligible.

RULE 81.—Nominations of candidates for election to the Council must be received by the Secretary not less than twenty-one days before the Annual General Meeting, with an intimation in writing by the candidates that they are willing to serve. Nominations must be signed by one supporter and two seconders, who must each be entitled to vote in the R.Ae.S.I.

Nominations must be received by March 10th, 1937, for this year's elections.

Council Meeting.

A Meeting of Council was held on Tuesday, February 9th, 1937, in the Offices of the Society.

Present.—Mr. H. E. Wimperis (President) in the chair; Major J. S. Buchanan, Major G. P. Bulman, Mr. H. Roxbee Cox, Professor F. T. Hill, Professor G. T. R. Hill, Major D. H. Kennedy (Honorary Treasurer), Captain A. G. Lamplugh, Mr. W. O. Manning, Mr. F. Handley Page, Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Mr. O. E. Simmonds.

Among the business discussed was the following:—Report of the Finance Committee; Report of the Grading Committee; Report of the Development Committee; Annual General Meeting; Draft Annual Report of the Council; Regulations for the R.38 Memorial Prize.

Elections.

The following recommendations of the Grading Committee were approved by the Council at their meeting on February 9th, 1937:—

Fellows.—Wallace Charles Devereux (from Associate Fellow), Frank Morgan Owner (from Associate Fellow).

Associate Fellows.—William Claude Cooper, Herbert Marcus Kemp, Robert Lang Lickley, Neil Shaw Muir, Miles Craven Rigby.

Associate.—John Gilbert McDonald.

Students.—Lionel Oscar Barnett, Dennis Bernard Clifford, George Henry Corbett, Eric Thomas Davies, Robert Niles East, William Harvey Hankin, Kenneth Walter Hetzel, Dennis Charles Jenkins, George Percy Jewell, Joseph Guy Lubbock, Basil M. Marsh, Lionel William Martin Nex, James Ronald Plenderleith, Harry Verdun Ramster, William Arthur Jevons Street, Leonard George Arthur Turner.

Companions.—Francis Gordon Tilstone Dudgeon, Eric Alexander Dorling, Robin Arthur Grosvenor, Douglas Maurice Limbery, Maldon Cavendish Harley.

Presidential Address.

On Monday, April 26th, 1937, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S., will deliver his Presidential Address in the Lecture Hall of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. The lecture will begin at 8 p.m.

At the beginning of his address the President will refer to the present position of the Royal Aeronautical Society, pointing out that there has recently been a gratifying increase in the membership, and that there is good reason to anticipate

that this healthy growth will continue in the coming years. There is an increasing realisation of the importance to aircraft construction of the free and open discussion at the meetings of the Society of the various intricate problems that arise. He expresses the thanks of the Society to their many benefactors for the support which has been given to their finances.

The main part of his address will be concerned with a statement of the problem of human flight as related to the laws of Nature, to which, like all else, it has to conform. One of the aspects of this problem is the relationship of those laws to the construction and performance of the airplane and its engine, the other is the physiological factors which limit the endurance of the human body, whether that of the pilot or his passengers. The President will endeavour to forecast in the light of present knowledge the limits thus imposed in respect of human flight.

The lecture will be followed by two films, one showing the humming bird in flight and the other the pelican, both at natural speed and in slow motion. The humming bird film, which was first shown at the Conversazione, is being shown again by special request. The pelican film will be shown for the first time to members at the meeting.

Garden Party.

The President and Council will hold a Garden Party on Sunday, May 9th, 1937, at the Great West Aerodrome, Hayes, by kind permission of Mr. C. R. Fairey, M.B.E., F.R.Ae.S. Further particulars will be published in the April Journal and sent out to each member.

Wilbur Wright Memorial Lecture.

The Wilbur Wright Memorial Lecture will be on "Turbulence," by Dr. Theodor von Kármán, F.I.Ae.S. The lecture will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, at 6.30 p.m.

Acknowledgments.

The President and Council desire to acknowledge with grateful thanks a copy of "L'Empire de l'Air" from Major Henri Jullerot, and a handbook on Renault Engines published in 1919 from Mr. W. O. Manning, F.R.Ae.S.

Additions to Library.

Report of the Air Survey Committee, No. 2, 1935. Published by the War Office.

Transactions of the Chartered Institute of Patents Agents, Volume LIV, Session 1935-1936.

The Construction of Wooden Aircraft. S. F. Wilkinson.

British Standard Glossary of Aeronautical Terms (Revised Edition).

The Air Annual of the British Empire, Volume III, 1937. (Foreign Supplement.)

Inspection of Aircraft after Overhaul. "B" Licence. S. J. Norton.

A Simple Study of Flight. J. D. Haddon. (3rd Edition.)

National Advisory Committee for Aeronautics. Twenty-first Annual Report containing Reports Numbers 508-541.

My Flying Life. Sir Charles Kingsford-Smith.

L'Empire de L'Air. L. P. Mouillard (1881).

Meteorology for Airmen in India. Part I. General Meteorological Features. Part II. Climatology of Air-Routes.

Renault Moteur D'Aviation, 220 Chevaux (1919).

The Conquest of the Stratosphere. Chas. C. Philp.

The Making and Moulding of Plastics. L. M. T. Bell.

Technical Publications of the International Tin Research and Development Council. Series A. Number 48. "The Production of Black Anodic Coatings on Tin and Tin Alloys," by R. Kerr and D. J. Macnaughtan.

Air Publication No. 1354. Air Photography. Organisation and Training.

Report of the Committee to consider the Development of Civil Aviation in the United Kingdom.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1724. Full-Scale and Model Resistances of a Southampton II Hull. E. T. Jones, L. Johnston and J. Hanson.

No. 1725. Turbulence Measurements in Flight. J. E. Serby and M. B. Morgan.

No. 1728. Note on Wind Tunnel Tests on a Parasol Monoplane with Zap and Split Flaps. J. H. Hartley and W. H. Curtis.

No. 1732. Note on Effects of Landing Flaps on Stability and Control. S. B. Gates.

No. 1737. Abstract. Notes on the Optimum Stiffness of Thin Shells. H. Roxbee Cox.

No. 1738. Abstract. Boundary Layer Growth. S. Goldstein and L. Rosenhead.

No. 1739. Abstract. Note on the Velocity Distribution in the Wake Behind a Flat Plate Placed Along the Stream. L. Rosenhead and J. H. Simpson.

No. 1743. Rolling Experiments on a "Puss Moth" Model. A. S. Batson, J. H. Warsap and H. J. Gummer.

No. 1745. Abstract. On the Static Pressure in Fully-Developed Turbulent Flow. A. Fage.

Forthcoming Events.

March 1st.—Lecture before Watford Grammar School, by Mr. W. O. Manning, F.R.Ae.S., on "How an Aeroplane is Made and Flies."

March 2nd.—Lecture before the Students' Section, in the Library, at 7, Albemarle Street, W.1, at 7 p.m., by Mr. J. C. Hardman on "Flaps." Mr. W. R. Andrews, A.F.R.Ae.S., in the chair.

March 4th.—Lecture before the City and Guilds' Engineering Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Queer Flying."

March 5th.—Lecture before Balshaw's Grammar School, by Mr. C. L. Old, on "How an Aeroplane is Made and Flies."

March 10th.—Lecture before the Southampton Branch, by Mr. F. M. Owner, M.Sc., A.F.R.Ae.S., on "Factors Controlling Aero Engine Development."

March 11th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m., Major B. C. Carter, M.I.Mech.E., F.R.Ae.S., A.R.C.Sc., D.I.C., on "Air-screw Blade Vibration."

March 11th.—Lecture before the Manchester Branch, by Mr. S. M. Parker, on "Hydraulic Services in Aircraft."

March 16th.—Discussion by the Students' Section in the Library at 7, Albemarle Street, at 7 p.m., on the paper by Mr. C. Moore, on "Stressed Skin Construction." (Read before the Students' Section on December 1st, 1936.)

March 16th.—Meeting of the Council at 7, Albemarle Street, W.1., at 5.30 p.m.

March 18th.—Lecture before the Coventry Branch on "Navigation," by Squadron Leader Godsave.

March 20th.—Visit by the Students' Section to the Airscrew Company, Weybridge, at 3 p.m.

March 31st.—ANNUAL GENERAL MEETING in the Library of the Society at 6.30 p.m. **All** voting members are asked to attend if possible.

April 6th.—Debate by the Students' Section, at 7 p.m., in the Library, at 7, Albemarle Street, W.1, on "Speed *v.* Safety in Civil Aircraft Design." Captain J. Laurence Pritchard, Hon. F.R.Ae.S., in the chair.

April 8th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m. Mr. A. G. Pugsley, M.Sc., A.M.I.Struct.E., on "Control Surface and Wing Stability Problems."

J. LAURENCE PRITCHARD, *Secretary and Editor*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

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MONTHLY NOTICES

APRIL, 1937

His Majesty The King.

The President and Council have great pleasure in announcing that His Majesty The King has been graciously pleased to become Patron of the Society.

Garden Party, May 9th, 1937.

On Sunday, May 9th, 1937, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S. and the Council will hold a Garden Party at the Great West Aerodrome, near Hayes, the use of which has kindly been given to the Society for the day by the Past-President, Mr. C. R. Fairey, M.B.E., F.R.Ae.S.

The Garden Party will begin at 2.30 p.m. with a reception by the President and Council, after which members and their guests will have an opportunity of watching a flying display and a parade of the many aircraft which will be present. There will be a static display of aircraft instruments, engines, etc., in one of the large hangars.

By permission of the Air Council the Band of H.M. Royal Air Force will play during the afternoon, under the direction of Squadron-Leader R. P. O'Donnell, M.V.O., Director of Music, R.A.F.

The President and Council extend a special welcome to ladies at the Garden Party. There will be ample cover in the marquees and hangar on the day.

Last year there were so many applications for tickets at the last minute that it was not possible to supply them all. It will very greatly help the work of the staff if members make application as soon as possible to avoid disappointment.

Council Meeting.

A Meeting of the Council was held on Tuesday, March 16th, 1937, in the Offices of the Society.

Present.—Mr. H. E. Wimperis (President) in the chair; Captain P. D. Acland, Major J. S. Buchanan, Major G. P. Bulman, Mr. H. Roxbee Cox, Professor F. T. Hill, Professor G. T. R. Hill, Mr. J. E. Hodgson (Honorary Librarian), Major D. H. Kennedy (Honorary Treasurer), Mr. W. O. Manning, Lieut.-Colonel J. T. C. Moore-Brabazon (Past-President), Mr. F. Handley Page (Vice-President), Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Lord Sempill, Mr. O. E. Simmonds, Mr. C. C. Walker.

Among the business transacted was the following:—Announcement that His Majesty the King had been graciously pleased to become Patron of the Society; Appointment of Scrutineers for the Council Ballot; Report of the Finance Committee; Report of the Grading Committee; Report of the Development Committee; proposed new premises for the Society.

Annual Subscriptions.

Under the Rules, members who have not paid their subscriptions for the current year by April 1st are not entitled to have the JOURNAL sent to them. It is not always possible to send back numbers of the JOURNAL to those who pay their subscriptions some time after April 1st, as many of the JOURNALS go out of print.

The Council wish to thank all those members who have been prompt in paying their subscriptions. By the members supporting the Society in this way it is possible to legislate ahead and make arrangements which effect considerable saving against having to work from month to month.

Income Tax.

In response to numerous inquiries with regard to a rebate on Income Tax for their subscriptions, the following is a copy of a letter received from the Principal Inspector of Taxes:—

"Ref. H.R.S. 34/C.I. 4420/63. 18/8/28.

Dear Sir,—Further to your interview with Mr. Stoneley at this office on the 19th July, I am now in a position to inform you that the Board of Inland Revenue will not raise objection to the allowance as an expense for Income Tax purposes of annual subscriptions paid by members who are:—

(i) Assessable under Schedule D of the Income Tax Acts in respect of professional or trading profits, subject to the decision of the Commissioners who make the assessment that such subscriptions are sufficiently closely related to the business carried on; or

(ii) Assessable under Schedule E in those cases only in which continual membership of the Society is an essential condition of the terms of appointment.

Yours faithfully,

(Signed) GEO. WILCOCK,

Principal Inspector of Taxes."

Presidential Address.

On Monday, April 26th, 1937, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S., will deliver his Presidential Address in the Lecture Hall of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. The lecture will begin at 8 p.m.

Immediately preceding the lecture the President will announce the awards of the medals and prizes for the year, and make their presentations on behalf of the Council.

At the beginning of his address the President will refer to the present position of the Royal Aeronautical Society, pointing out that there has recently been a gratifying increase in the membership, and that there is good reason to anticipate that this healthy growth will continue in the coming years. There is an increasing realisation of the importance to aircraft construction of the free and open discussion at the meetings of the Society of the various intricate problems that arise. He expresses the thanks of the Society to their many benefactors for the support which has been given to their finances.

The President hopes to make an important announcement about the future of the Society which will affect all members and lead to a great advance in the activities and prestige of the Society.

The main part of his address will be concerned with a statement of the problem of human flight as related to the laws of Nature, to which, like all else, it has to

conform. One of the aspects of this problem is the relationship of those laws to the construction and performance of the airplane and its engine, the other is the physiological factors which limit the endurance of the human body, whether that of the pilot or his passengers. The President will endeavour to forecast in the light of present knowledge the limits thus imposed in respect of human flight.

The lecture will be followed by two films, one showing the humming bird in flight and the other the pelican, both at natural speed and in slow motion. The humming bird film, which was first shown at the Conversazione on January 12th, 1937, is being shown again by special request. The pelican film will be shown for the first time to members at the meeting.

Wilbur Wright Lecture.

The Wilbur Wright Memorial Lecture will be given this year by Dr. Theodor von Kármán, F.I.Ae.S., on "Turbulence." The lecture will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, on May 27th, at 6.30 p.m., and will be followed by the Annual Council Dinner to the lecturer.

Election of Members.

The following recommendations of the Grading Committee were approved by the Council at their meeting on March 16th, 1937:—

Associate Fellows.—J. G. Brown, F. G. Gardner, E. J. Gregson, F. Hauptmann, W. M. Page, J. H. Preston, G. Silyn Roberts, F. T. Watts, G. B. Vinycomb.

Associate Members.—M. G. Hunn, W. W. T. Sawyer.

Associates.—R. K. B. Bridges, Alan S. Butler, A. E. McLaren, E. S. Millett.

Students.—H. Clark, W. H. Coulthard, K. R. Davies, H. A. G. James, A. W. H. Jamieson, J. K. Keelaghan, J. P. Lassam, R. Maine, J. K. Marshall, J. B. Mills, R. M. Leach, H. G. S. Peacock, J. Phillips, W. H. Riley, H. G. W. Turner, P. P. Whaley.

Companions.—Lieut.-Col. M. O. Darby, Alexander Gross, A. O. Pollard, R. A. Robbins, A. M. Tucker.

Engineering Institute of Canada.

The Engineering Institute of Canada, with which the branches of the Society in Montreal and Ottawa are affiliated, is holding its semi-centennial celebrations on June 15th, 16th and 17th, 1937, at Montreal. At the meeting a series of technical papers dealing with the main branches of engineering will be read of international as well as Canadian note and interest. Luncheon meetings will be arranged at which addresses on more general subjects will be given by prominent speakers, and many official delegates will be present from engineering societies in other countries.

Visits will be arranged to engineering works and other points of interest and special arrangements will be made for the entertainment of ladies. On Friday, June 18th, the meetings will be continued at Ottawa, the seat of the Dominion Government, where a programme of interest will be arranged.

The Engineering Institute has branches in Toronto, Hamilton and other important centres and arrangements will be made to receive delegates and others who visit these centres.

The Council have appointed Mr. H. E. Wimperis, C.B., C.B.E., F.R.Ae.S. (President), to represent the Society. It is particularly requested that any member of the Society who is visiting Canada on that date will get in touch with the Secretary as soon as possible.

International Technical Conference on Aerial Relief.

The First International Technical Conference on Aerial Relief will be held in Budapest from June 11th-14th, 1937. There will be demonstrations and competitions and interested members are asked to communicate with the Secretary of the Conference at Baross-utca 15, Budapest, VIII, Hungary.

University College, London (Engineering Society).

The Engineering Society of University College has in preparation the first issue of a Year Book, which will be sent free to former students. Will old members kindly send in their names, addresses, years at college, academic and professional qualifications, present appointment, and news of their contemporaries, to P. H. Walker, Engineering Department, University College, Gower Street, W.C.1.

International Association for Testing Materials, International Congress, April 19th—24th, 1937.

A Congress on the International Testing of Materials will be held in London from April 19th to April 24th, 1937. Full particulars may be obtained from the Organising Secretary, Mr. K. Headlam-Morley, 28, Victoria Street, S.W.1.

Acknowledgments.

The Council gratefully acknowledge the gift of three slides from Mr. H. E. Wimperis, President of the Society. They would also like to acknowledge the gift of early aeronautical books from the Yeovil Branch and back copies of the JOURNAL and copies of the " Journal of Scientific Instruments " from Mr. F. P. Walsh, Associate Fellow.

Endowment Fund.

The Council gratefully acknowledge a cheque for £1 1s. 0d. towards the Endowment Fund from Mr. J. W. C. Logan, Associate Member. Mr. Logan has made a similar donation for the past five years and his action is much appreciated.

Additions to the Library.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1710. Tests on Two Streamline Bodies in the Compressed Air Tunnel. R. Jones, D. H. Williams and A. F. Brown.

No. 1726. An Analytical Comparison of Model and Full-Scale Spinning Experiments on a Bristol Fighter. R. P. Alston and J. Cohen.

No. 1730. The Flight of a Helicopter. H. B. Squire.

No. 1733. A New Form of Dash Pot with a Large Range of Damping. A. S. Halliday.

No. 1747. Further Measurements of Ground Interference on the Lift of a Southampton Flying Boat. J. L. Hutchinson.

No. 1750. Reports and Memoranda Published between 1st April, 1935, and 30th November, 1936.

No. 1752. Calibration of Standard Pitot-Static Heads in the High-Speed Tunnel. C. N. H. Lock and W. F. Hilton.

Reports of the National Advisory Committee for Aeronautics:—

No. 562. Air Flow in the Boundary Layer Near a Plate. Hugh L. Dryden.

No. 568. The Quiescent-Chamber Type Compression-Ignition Engine. H. H. Foster.

No. 571. Pressure Distribution over a Rectangular Airfoil with a Partial-Span Split Flap. C. J. Wenzinger and Thomas A. Harris.

No. 572. Determination of the Characteristics of Tapered Wings. Raymond F. Anderson.

No. 573. Aerodynamic Characteristics of N.A.C.A. 23012 and 23021 Airfoils with 20 per cent. Cord External-Airfoil Flaps of N.A.C.A. 23012 Section. Robert C. Platt and Ira H. Abbott.

No. 574. Pressure Distribution Over an Airfoil Section with a Flap and Tab. Carl J. Wenzinger.

No. 578. Flight Measurements of the Dynamic Longitudinal Stability of Several Airplanes and Co-relation of the Measurements with Pilots' Observations of Handling Characteristics. Hartley A. Soule.

Technical Notes of the National Advisory Committee for Aeronautics:—

No. 580. A General Tank Test of a Model of the Hull of the British Singapore IIC Flying Boat. John H. Dawson and Starr Truscott.

No. 582. Analysis and Model Tests of Autogiro Jump Take-Off. John B. Wheatley and Carlton Bioletti.

No. 583. Mixture Distribution in a Single-Row Radial Engine. Harold C. Gerrish and Fred. Voss.

No. 584. Effect of Several Factors on the Cooling of a Radial Engine in Flight. Oscar W. Schey and Benjamin Pinkel.

No. 585. Mechanical Properties of Aluminium-Alloy Rivets. Wm. C. Brueggeman.

Air Estimates, 1937.

Memorandum by the Secretary of State for Air to Accompany Air Estimates for 1937.

Twenty-Second Administrative Annual Report of the National Advisory Committee for Aeronautics, 1936.

Journées Techniques Internationales De L'Aéronautique. Chambre Syndicale des Industries Aéronautiques.

A La Mémoire de Henry le Chatelier 1850-1936, Revue de Métallurgie.

The 4th International Aviation Meeting, Zurich, 1937. July 23rd-August 1st, Aero Club de Suisse.

Brass Pressing, Copper Development Association.

The Systems Tin-Germanium and Tin-Beryllium. Professor W. Guertler and M. Pirani. International Tin Research and Development Council.

Reports on Progress in Physics, Volume III, The Physical Society.

Airman Friday. William Courtenay.

Thermodynamics Applied to Heat Engines, 2nd Edition. E. H. Lewitt.

Handbook of Information Including Indexed Lists of British Standard Specifications and Methods of Test. British Standards Institution.

Ballistische Gegevens van Vliegtuigbommen. Dr. Ir. G. Otten.

Zum Neudruck der Vorschriften für die Festigkeit von Flugzeugen. Arthur Neesen and Alfred Teichmann.

Theoretical and Experimental Studies of Convectional Circulation and its Relation to Land and Sea Breezes. T. Kobayashi and T. Saski.

The Romance of Exploration and Emergency First Aid from Stanley to Byrd. Chicago Century of Progress Exposition 1934.

Revision of Ordnance Survey 25-inch Plans from Air Photographs. Major R. Ll. Brown, R.E.

Junkers-Nachrichten. Fernflug Dessau-Australien mit Junkers-Ju 86.

Journal of the Institute of Metals, Volume LIX.

Résumé of Commercial Information. Number of Registered Civil Aircraft. Special issue No. 1/1937.

University of London Centenary, 1836-1936.

The Efficiency of Return Flow Wind Tunnels. Frank L. Wattendorf.

The Energy Ratio of the Tsing Hua University Wind Tunnel. F. L. Wattendorf, K. L. Feng and C. C. Chang.

Elementary Aeronautics. A. P. Thurston.

Aerodonetics (2nd Edition). F. W. Lanchester.

Flight Without Formulæ (2nd Edition). Commandant Duchene. (Translated from the French by J. H. Ledeboer.)

La Résistance de L'Air. Examen des Formules et des Expériences. G. Eiffel.

Airscrews. M. A. S. Riach.

The Making and Moulding of Plastics. L. M. T. Bell.

Forthcoming Events.

April 6th.—Debate by the Students' Section, at 7 p.m., in the Library of the Society, at 7, Albemarle Street, W.1, on "Speed *v.* Safety in Civil Aircraft Design." Captain J. Laurence Pritchard, Hon. F.R.Ae.S., in the chair.

April 8th.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, John Street, Adelphi, W.C.2, at 6.30 p.m. Mr. A. G. Pugsley, M.Sc., A.M.I.Struct.E., on "Control Surface and Wing Stability Problems."

April 8th.—Lecture before the Manchester Branch, by Major T. M. Barlow, M.Sc., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S., on "Aircraft Production."

April 12th.—Meeting of Council in the Offices of the Society at 5.30 p.m.

April 14th.—Lecture before the Southampton Branch, by Captain A. Graham Forsyth, on "Modern Airscrew Development."

April 15th.—Lecture before the Coventry Branch, by Mr. S. J. Harley, B.Sc., on "Production and Inspection Methods Applied to Screw Threads."

April 20th.—Lecture before the Students' Section on "Aircraft Design from a Pilot's Point of View," by Captain J. H. Cordes, in the Library, at 7, Albemarle Street, W.1, at 7 p.m.

April 22nd.—Lecture before the Society in the Lecture Hall of the Royal Society of Arts, 18, John Street, Adelphi, W.C.2, at 6.30 p.m. Mr. G. J. Mead, A.F.R.Ae.S., on "Power Plant Trends."

April 24th.—Visit by the Students' Section to the Royal Aircraft Establishment. British subjects only.

April 26th.—Lecture before the Society by the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S., on "The Natural Limits to Human Flight."

May 9th.—Garden Party at the Great West Aerodrome, Hayes, 2.30 to 7 p.m. Tickets 5/- each.

May 19th.—Associate Fellowship and Associate Membership Examinations in the Offices of the Society, at 7, Albemarle Street, W.1.

May 20th.—Associate Fellowship and Associate Membership Examinations in the Offices of the Society, at 7, Albemarle Street, W.1.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

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MONTHLY NOTICES
MAY, 1937

Garden Party, May 9th, 1937.

On Sunday, May 9th, 1937, the President, Mr. H. E. Wimperis, C.B., C.B.E., M.A., F.R.Ae.S. and the Council will hold a Garden Party at the Great West Aerodrome, near Hayes, the use of which has kindly been given to the Society for the day by the Past-President, Mr. C. R. Fairey, M.B.E., F.R.Ae.S.

The Garden Party will begin at 2.30 p.m. with a reception by the President and Council, after which members and their guests will have an opportunity of watching a flying display and a parade of the many aircraft which will be present. Many of the latest military and civil aircraft will be seen at the Garden Party. There will be a static display of aircraft instruments, engines, model aircraft, etc., in one of the large hangars.

By permission of the Air Council the Band of H.M. Royal Air Force will play during the afternoon, under the direction of Squadron-Leader R. P. O'Donnell, M.V.O., Director of Music, R.A.F.

The President and Council extend a special welcome to ladies at the Garden Party. There will be ample cover in the marquees and hangar on the day.

Last year there were so many applications for tickets at the last minute that it was not possible to supply them all. It will very greatly help the work of the staff if members make application as soon as possible to avoid disappointment.

Office Closing.

The Offices of the Society will be closed on May 12th, 1937, and Whit Monday, May 17th, 1937.

Associate Fellowship and Associate Membership Examinations.

The Library will be closed on Wednesday and Thursday, May 19th and May 20th, for the Associate Fellowship and Associate Membership Examinations.

Council Meeting.

A Meeting of Council was held in the Offices of the Society on Monday, April 12th, 1937. The following members were present:—Mr. H. E. Wimperis (President) in the chair; Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. H. Hall, Professor F. T. Hill, Professor G. T. R. Hill, Major D. H. Kennedy (Honorary Treasurer), Lieut.-Colonel W. Lockwood Marsh, Mr. F. Handley Page, Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Mr. D. R. Pye and Mr. E. F. Relf.

Among the business discussed was the following:—Proposed New Premises for the Society; Report of the Finance Committee; Report of the Grading Committee; Report of the Medals and Awards Committee; Appointment of

Committees of Council and Representatives on other Bodies; Resolution from the Annual General Meeting; Empire Air Day.

Election of Members.

The following members were elected at a meeting of Council held on Monday, April 12th, 1937:—

Fellows.—T. P. Wright, W. G. Carter.

Member.—A. R. Code.

Associate Fellows.—H. St. G. Burke, H. Cantrill, W. H. Golder, A. W. B. McDonald, W. F. Pharazyn, H. V. Rowley, C. Turner, E. W. C. Wilkins.

Associate Members.—W. H. Brooks, E. F. Carpenter, R. J. Fyfe, E. Holden, J. A. Sheppard.

Associates.—F. D. Aldridge, A. D. Ferguson.

Students.—M. C. Goodall, S. R. Lewis, H. M. Will.

Companions.—A. R. Hallock, G. S. Morrison.

Awards.

At a meeting of Council held on April 12th, 1937, the following Awards were made:—

Society's Gold Medal.—Awarded to the late Senor J. de la Cierva, F.R.Ae.S., for his work on the development of the Autogiro.

Society's Silver Medal.—Awarded to F. W. Meredith, B.A., for his work on the Automatic Pilot.

Society's Silver Medal.—Awarded to P. A. Cooke, O.B.E., M.C., for his work on the Automatic Pilot.

British Gold Medal for Aeronautics.—Awarded to A. Gouge, B.Sc., F.R.Ae.S., for his achievement in the development of Flying Boats.

Simms Gold Medal.—Awarded to Dr. H. Gough, M.B.E., F.R.S., for his paper "New Light on the Strength of Materials Afforded by Modern Physics."

Simms Gold Medal.—Awarded to W. A. Wood for his paper on "New Light on the Strength of Materials Afforded by Modern Physics."

Taylor Gold Medal.—Awarded to Dr. G. P. Douglas, M.C., A.F.R.Ae.S., for his paper on "Cooling Problems with Particular Reference to the Work of the 24ft. R.A.E. Tunnel."

Edward Busk Memorial Prize.—Awarded to Mr. G. H. Dowty, F.R.Ae.S., for his paper on "Retractable Undercarriages."

Pilcher Memorial Prize.—Awarded to H. Leaderman, B.A., B.Sc. (Eng.), for his paper on "The Fundamentals of Boundary Layer Theory with Some Applications to Aircraft."

Wilbur Wright Lecture.

The Wilbur Wright Memorial Lecture will be given this year by Dr. Theodor von Kármán, F.I.Ae.S., on "Turbulence." The lecture will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, on May 27th, at 6.30 p.m., and will be followed by the Annual Council Dinner to the lecturer.

Non-members will only be admitted by ticket obtained through a member.

Engineering Institute of Canada.

The Engineering Institute of Canada, with which the branches of the Society in Montreal and Ottawa are affiliated, is holding its semi-centennial celebrations

on June 15th, 16th and 17th, 1937, at Montreal. At the meeting a series of technical papers dealing with the main branches of engineering will be read of international as well as Canadian note and interest. Luncheon meetings will be arranged at which addresses on more general subjects will be given by prominent speakers, and many official delegates will be present from engineering societies in other countries. The President, Mr. H. E. Wimperis, will be officially representing the Society at the celebrations.

Visits will be arranged to engineering works and other points of interest and special arrangements will be made for the entertainment of ladies. On Friday, June 18th, the meetings will be continued at Ottawa, the seat of the Dominion Government, where a programme of interest will be arranged.

The Engineering Institute has branches in Toronto, Hamilton and other important centres and arrangements will be made to receive delegates and others who visit these centres.

Acknowledgments.

The Council gratefully acknowledge the gift of two copies from Dr. F. W. Lanchester, Honorary Fellow, of "The Cylinder Cooling of Internal Combustion Engines"; and the gift of engine photographs from Mr Leonard Bridgman.

Additions to the Library.

The Industrial Arts Index, 1936. Twenty-fourth Annual Volume.
The Daniel Guggenheim Medal. Biographies of Recipients.
The Interference Effect of the Surface of the Sea on the Lift of a Seaplane. Report No. 146 of the Aeronautical Research Institute, Tokyo Imperial University. (February, 1937.)
Synopsis of British Air Effort During the War. H.M.S.O., 1919.
Concrete in Aerodrome Construction. The Cement and Concrete Association.
Air Force Constitution Act, 1917. H.M.S.O.
The Cylinder Cooling of Internal Combustion Engines, by Dr. F. W. Lanchester (two copies). Presented by the Author.

Reports and Memoranda of the Aeronautical Research Committee:

No. 1727. The Effect of Blade Twist on the Characteristics of the C.30 Autogiro, by J. A. Beavan and C. N. H. Lock.
No. 1729. Wind Tunnel Tests of High Pitch Airscrews. Part II. Variations of Blade Width and Blade Section, by C. N. H. Lock and H. Bateman.
No. 1740. Note on Performance Data for Honeycomb Radiators in a Duct, by A. S. Hartshorn.
No. 1742. The Wing Stiffness of Monoplanes, by A. G. Pugsley. With an Appendix on the Measurement of Wing Stiffness, by A. G. Pugsley and A. W. Clegg.
No. 1744. On the Erosion of Sparking Plug Electrode Materials and the Variation of Sparking Plug Voltage, by W. R. Debenham and F. G. Haydon.
No. 1748. The Stressing of a Particular Rigid-Jointed Fuselage under Bending Loads, by J. Morris and G. C. Abel.
No. 1754. Abstract. Turbulent Flow in a Circular Pipe. A. Fage.

Research on Thin Layers of Tin and Other Metals. III. The Interaction Between Metals and Lubricating Oils, by F. J. Haringhuizen. (Technical Publications of the International Tin Research and Development Council.)
Journal of the British Interplanetary Society. February, 1937.
Air Over Eden, by "H. W." and Sydney Hay.
The Airman and the Air, by A. B. Fielding.

An Introduction to Fluid Mechanics, by Alex. H. Jameson.
The Materials of Aircraft Construction, by F. T. Hill. (3rd Edition.)
B.B.C. Annual, 1937.
Synthetic Rubber, by W. J. S. Naunton.
The Complete Air Navigator. Covering the Syllabus for the First Class Air Navigation Licence, by D. C. T. Bennett.
Air Transportation Costing, by Captain N. T. Macleod.
25 Jahre Luftkutscher, by Robert Gsell.
Flying Years, by C. H. Keith.

Reports of the National Advisory Committee for Aeronautics:—

No. 567. Propulsion of a Flapping and Oscillating Airfoil, by I. E. Garrick.

No. 570. The Effect of Lateral Controls in Producing Motion of an Airplane as Computed from Wind Tunnel Data, by Fred. E. Weick and Robert T. Jones.

No. 579. A Study of the Two-Control Operation of an Airplane, by Robert T. Jones.

No. 580. Heat Transfer to Fuel Sprays Injected into Heated Gases, by Robert F. Selden and Robert C. Spencer.

No. 583. The Rolling Friction of Several Airplane Wheels and Tyres and the Effect of Rolling Friction on Take-off, by J. W. Wetmore.

Technical Notes of the National Advisory Committee for Aeronautics:—

No. 586. The Reduction of Aileron Operating Force by Differential Linkage, by Robert T. Jones and Albert I. Nerken.

No. 587. The Forces and Moments on Airplane Engine Mounts, by Philip Donely.

No. 588. Strain Measurements on Small Duralumin Box Beams in Bending, by Paul Kuhn.

Forthcoming Events.

Sunday, May 9th.—Garden Party, Great West Aerodrome, Hayes.

Wednesday, May 19th.—Associate Fellowship and Associate Membership Examination in the Offices of the Society, at 7, Albemarle Street, W.1.

Thursday, May 20th.—Associate Fellowship and Associate Membership Examination in the Offices of the Society, at 7, Albemarle Street, W.1.

Saturday, May 22nd.—Visit of the Students' Section to Gatwick Airport, 2.30 p.m.

Tuesday, May 25th.—Meeting of Council in the Offices of the Society.

Thursday, May 27th.—Wilbur Wright Memorial Lecture by Doctor Th. von Kármán, F.I.Ae.S., on "Turbulence," in the Lecture Theatre of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, at 6.30 p.m.

J. LAURENCE PRITCHARD, *Secretary and Editor*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

JUNE, 1937

The President.

The President, Mr. H. E. Wimperis, sails on the " Empress of Britain " on June 5th for Canada, where he will act as the Society's representative at the Semi-Centenary Celebrations of the Engineering Institute of Canada, and present an Illuminated Address to the Institute from the Society.

The Illuminated Address is worded as follows:—

> The President, Council and Members of the Royal Aeronautical Society desire to offer to the President, Council and Members of the Engineering Institute of Canada their sincere congratulations on the occasion of the Celebrations of the Fiftieth Anniversary of the Foundation of the Institute.
>
> The growth of the Institute during those fifty years and the energy with which it has promoted the utilisation of the forces of nature for the benefit of mankind has won the admiration and respect of all who follow the progress of Engineering Science throughout the World.
>
> The members of the Royal Aeronautical Society value most highly the friendly relationship that exists between the two Societies and are glad to have this notable opportunity to express their cordial wishes for the continuing welfare and prosperity of the Engineering Institute of Canada.
>
> Witness our hands and Seals at London this first day of June, 1937,
>
> H. E. WIMPERIS, *President.*
>
> J. LAURENCE PRITCHARD, *Secretary.*

While in Canada the President will take the opportunity of meeting many members of the Society and getting in touch with the Canadian Branches. From Canada the President will sail for Australia, where he will meet members of the Australasian Branch. The President expects to return to England in June, 1938.

Council Meeting.

A Meeting of Council was held on Tuesday, May 25th, 1937, in the Offices of the Society.

Present.—Mr. H. E. Wimperis (President) in the chair; Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. H. R. Fedden, Mr. A. H. Hall, Professor F. T. Hill, Professor G. T. R. Hill, Mr. W. O. Manning, Lieut.-Col. W. Lockwood Marsh, Mr. F. Handley Page, Dr. N. A. V. Piercy, Mr. D. R. Pye, Mr. E. F. Relf, Lord Sempill and Mr. L. A. Wingfield. Major J. S. Buchanan, Chairman of the Finance Committee, in attendance.

Among the business for discussion was the following:—Report of the Finance Committee; Report of the Grading Committee; Nominations for the President and Vice-Presidents for the year 1937-1938; formation of a Branch in the Isle of Wight; suggested appointment of an Inventions Committee.

Elections.

The following recommendations of the Grading Committee were approved by the Council at their meeting on May 25th, 1937:—

Fellow.—Thomas Swinden (from Associate Fellow).

Associate Fellows.—John Allan Beavan, Hedley S. Crabtree, Robert Victor Goddard, John Malcolm Gray, Leslie Milkington Iles, Masaiti Kondo, Laurence Thomas George Mansell, Frederick William Meredith, Thomas Pitt de Paravicini, George Parkin, Arthur Alexander Rubbra, Tom Roberts Thomas, Ernest William Howarth Thompson, Harry Wood.

Associate Member.—Edwin Sidney Street.

Associate.—John Stanley Orme.

Graduate.—Roland Towers.

Students.—Jack William Guy Comfort, Sidney Graham Heath, Daniel McQueen, James Cedric Paterson, John Bodan Ross, Gervase Robinett Scruby.

Companions.—Freeman Horn, Cyril Campbell Login, Hetman Jack Parham, Dady Rustum Wadia.

Library to be Closed on Saturday Afternoons.

The Library will be closed on Saturday afternoons from Saturday, June 26th and will re-open on Saturday, September 4th, 1937. Members may obtain books from the Library through the post on application to the Office. The Library will be open as usual from 9.30 to 5 o'clock from Monday to Friday and from 9.30 to 12.30 on Saturdays.

Additional Telephone Line.

Will members please note that an additional telephone line has now been installed in the Office and the number is **Regent 2736.**

Acknowledgments.

The Council acknowledge with thanks the return of Journals by the following Members:—Mrs. J. D. Fullerton (Companion), Miss Etty-Leal (Student) and Mr. R. M. A. Rice (Student), and copies of "Flight" from Mr. S. W. Slaughter (Associate).

Endowment Fund.

The Council wish to acknowledge with grateful thanks the gift of eight shillings to the Endowment Fund from Squadron Leader G. P. Tzannetakis (Associate Fellow).

Students' Visit.

The Students' Section will pay a visit to the works of Airspeed (1934), Limited, Portsmouth Airport, at 10 a.m. on Saturday, June 19th, and to Messrs. Saunders-Roe, Limited, Cowes, at 3.0 p.m. on the same day. Students who intend joining the party to these works should inform the Honorary Secretary of the Students' Section, at 7, Albemarle Street, W.1, by June 8th, stating whether they wish to avail themselves of the party ticket facilities.

Lectures.

The Lectures Committee will meet early this month to consider the lecture programme for the 1937-1938 Session. If members have any suggestions to make the Council will be glad to have them as soon as possible.

Additions to the Library.

The Firth-Brown Research Laboratories.

Some Problems of Modern High-Duty Aero Engines and their Fuels, by F. R. Banks.

Aerodromes and Hangars. The Architect and Building News.

Repertorium Technicum, Nos. 1, 2, 3 and 4. Nederlandsch Instituut voor Documentatie en Registratuur.

The National Physical Laboratory Report, 1936.

An Investigation into the Variation of the Lapse Rate of Temperature in the Atmosphere near the Ground at Ismailia, Egypt. Meteorological Office Geophysical Memoirs No. 71. H.M.S.O.

Index of Welding Literature.

The Use of Tin in Refrigerating Equipment, by E. J. Daniels and D. J. Macnaughtan. (Technical Publications of the International Tin Research and Development Council.)

The Tinning of Steel Strip by Electrodeposition, by D. J. Macnaughtan and J. C. Prythergh. (Technical Publications of the International Tin Research and Development Council.)

World Power Conference Annual Report, 1936. Central Office of the World Power Conference.

The Science of Petroleum.

Vibration Phenomena in Ternary Wing Flutter. Report No. 147 of the Aeronautical Research Institute, Tokyo Imperial University. (April, 1937.)

The Institution of Professional Civil Servants. Annual Report of Council for the year 1936.

Transactions of the Institute of the Plastics Industry, January, 1937.

Résumé of Commercial Information. Compiled by the Department of the Director-General of Civil Aviation, Air Ministry.

Reports of the National Advisory Committee for Aeronautics:—

No. 575. Interference of Wing and Fuselage from Tests of 28 Combinations in the N.A.C.A. Variable Density Tunnel, by Albert Sherman.

No. 577. Pre-chamber Compression Ignition Engine Performance, by Charles Moore and John Collins, Jun.

No. 581. Measurements of Intensity and Scale of Wind Tunnel Turbulence and Their Relation to the Critical Reynolds Number of Spheres, by H. Dryden, G. B. Schubauer, W. C. Mock, Jun., and H. K. Skramstad.

No. 582. A Theory for Primary Failure of Straight Centrally Loaded Columns, by E. E. Lundquist and C. Fligg.

No. 584. Strength of Welded Aircraft Joints, by W. C. Brueggeman.

Technical Notes of the National Advisory Committee for Aeronautics:—

No. 589. Theoretical Span Loading and Moments of Tapered Wings Produced by Aileron Deflection, by H. Pearson.

No. 590. Hydrodynamic Tests in the N.A.C.A. Tank of a Model of the Hull of the Short Calcutta Flying Boat, by Kenneth E. Ward.

No. 591. Full-Scale Span Load Distribution on a Tapered Wing with Split Flaps of Various Spans, by John F. Parsons and Abe Silverstein.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1723. The Influence of Differential Aileron Control on Wing Flutter, by R. A. Frazer.

No. 1746. Airscrew Theory. (A paper delivered before the Fourth International Congress for Applied Mechanics, Cambridge, 1934.) By C. N. H. Lock.

No. 1749. The Strength of Lugs, by W. D. Douglas.

No. 1753. Full-Scale Trials on Scion M.3 with a Gouge Flap, by J. Cohen.

No. 1759. (Abstract.) Some Applications of Conformal Transformation to Airscrew Theory, by F. L. Westwater.

Report for Years 1935 and 1936 of the Aeronautical Research Committee.
L'Envol, by Robert Gastambide.
The Modern Diesel. Iliffe and Sons, Ltd. (4th Edition.)
The Technology of Aluminium, by Dr. Ing. Afred Von Zeerleder.
Metal Aircraft Construction, by M. Langley. (3rd Edition.)
Interpretive History of Flight, by M. J. B. Davy. Science Museum.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

JULY, 1937

Election of President.

Mr. H. E. Wimperis, C.B., C.B.E., M.A., M.I.E.E., F.R.Ae.S., was re-elected President of the Society for the year 1937-1938 by the Council.

Vice-Presidents.

The following Vice-Presidents were elected by the Council:—
Mr. F. Handley Page, C.B.E., F.R.Ae.S.
Mr. A. H. R. Fedden, M.B.E., M.I.A.E., M.S.A.E., F.R.Ae.S.
Mr. A. H. Hall, C.B., C.B.E., M.Inst.C.E., M.I.Mech.E., F.R.Ae.S.
Mr. D. R. Pye, C.B., M.A., M.I.Mech.E., F.R.Ae.S.

Council Meeting.

A meeting of Council was held in the Offices of the Society on Tuesday, June 8th, 1937. Present: Mr. F. Handley Page (Vice-President) in the Chair; Mr. Robert Blackburn, Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. Gouge, Mr. A. H. Hall, Professor F. T. Hill, Professor G. T. R. Hill, Major D. H. Kennedy (Hon. Treasurer), Mr. W. O. Manning, Lt.-Col. W. Lockwood Marsh, Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Mr. D. R. Pye, and Mr. E. F. Relf.

Among the business discussed was the following: Report of the Finance Committee; Report of the Grading Committee; Report of the Lectures Committee; Correspondence regarding the Garden Party; annual awards of the Society.

Election of Members.

The following recommendations of the Grading Committee were approved by the Council at their meeting on June 8th, 1937:—

Fellow.—Thomas George John.

Associate Fellows.—Richard Cox Abel, Frederick George Liddiard Amer, Harold John Cardnell Harper, Chih-Bing Ling, Albert James Mott, Sydney Joseph Nightingale, Richard Arthur Robbins, Edward Tyler, James Henry Winch.

Associate Members.—John Fort, John Desmond Loraine Stratton.

Associates.—Henry Charles Brown, Frank Holliday, Lewis Larsen.

Graduates.—Stewart Kevern Hambling, Edward Loveless, Peter Herbert Rayner.

Students.—Eric Raymond Arbon, Suriel Kumar Banerjee, Peter Crolla, Albert Leonard Bryant, Wilfred Barwell Holroyd, John Anthony McGoff, George Harold Thomas.

Companion.—Mrs. Walker Sinclair.

R.38 Memorial Prize.

The R.38 Memorial Prize is offered annually for the best paper received by the Society on some subject of a technical nature in the science of aeronautics. Awards in the past have given preference to airship papers. It should be noted, however, that the prize is given for the best paper on some subject of a technical nature in the science of aeronautics. In view of the present position of airships in this country the Council will welcome entries on subjects coming within the general scope of the prize on aircraft generally. Papers should be typewritten and submitted in triplicate, and may be accompanied by illustrations or not. The prize is twenty-five guineas.

Library Closing.

Members are reminded that the Library will be closed on Saturday afternoons from June 26th and will re-open on September 4th. The Library will also be closed on August Bank Holiday, August 2nd.

Associate Fellowship and Associate Membership Examinations.

The following candidates were successful at the examinations held in May, 1937:—

ASSOCIATE FELLOWSHIP.

J. L. Burbidge ...	Applied Mathematics (First Place). Theory of Internal Combustion Engines. Design (Aero Engines).
D. A. Clifton-Mogg ...	Applied Mathematics.
A. E. Draper	Pure Mathematics.
H. M. Gardiner ...	Theory of Internal Combustion Engines. Design (Aero Engines).
M. A. F. Hirst ...	Pure Mathematics (First Place). Aerodynamics. Design (Aircraft).
D. M. Jameson ...	Theory of Internal Combustion Engines (First Place)
B. V. Leak	Applied Mathematics. Strength of Aeronautical Materials. Design (Aircraft).
F. H. M. Lloyd ...	Strength of Aeronautical Materials.
C. H. Nundy	Strength of Aeronautical Materials.
H. G. S. Peacock ...	Strength of Aeronautical Materials. Aerodynamics.
F. H. Pollicutt ...	Pure Mathematics. Strength of Aeronautical Materials (First Place). Design (Aircraft) (First Place).
C. A. Ridgwell ...	Pure Mathematics. Aerodynamics.
J. Smith	Aerodynamics.
R. Towers	Aircraft Materials.
W. A. C. Weetman ...	Strength of Aeronautical Materials. Design (Aircraft).
A. P. West	Pure Mathematics.
M. B. Williams ...	Theory of Internal Combustion Engines.
P. N. Willoughby ...	Applied Mathematics.
E. A. Wright	Aerodynamics (First Place).

ASSOCIATE MEMBERSHIP.

C. R. P. Bizeray	...	Strength of Aeronautical Materials.
F. G. T. Dudgeon	...	Theory of Internal Combustion Engines. Aircraft Materials.
F. Kendall ...	...	Applied Mathematics. Strength of Aeronautical Materials. Design (Aircraft).
K. C. T. Marshall	...	Applied Mathematics (First Place).
R. C. Pike ...	...	Applied Mathematics.
C. G. Saunders	...	Aircraft Materials.

Acknowledgments.

The Council acknowledge with grateful thanks the gift of the German Edition of Aerodynamics and the French Editions of Aerodynamics and Aerodonetics by Dr. F. W. Lanchester from the Author, lantern slides from Miss Glazebrook from the collection of the late Sir Richard Glazebrook, and the gift of back Journals from Mr. A. G. Taylor, Student.

Library Books.

The attention of members is drawn to the rule that no book may be borrowed for more than three weeks at a time. There is a heavy demand for certain books in the library and in future this rule will be rigidly adhered to. It should be noted that books may not be borrowed for the purpose of using as text books in examinations. The library books are for reference.

Additions to the Library.

Sailplanes: Their Design, Construction and Pilotage, C. H. Latimer Needham.
Brown's Nautical Almanac, 1937.
The Aircraft Year Book for 1937.
Einige Eigenschaften von Magnesium Blech und Legierungen, von Masaharu Goto, Mosu Nito and Hirosi Asada. Report No. 148 of the Aeronautical Research Institute of Tokyo Imperial University.
Temperature and Relative Humidity in the Atmosphere over Lower Egypt, William D. Flower.
The Normal Atmosphere above Rio de Janeiro, Adalberto B. Serra and Lauro D. Barbosa.
Fluid Mechanics, Dodge and Thompson.
Proceedings of the Institution of Mechanical Engineers, Volume 134.
The Effect of Cold-Work and Annealing on the Hardness of Some Tin-Antimony, Tin-Antimony-Copper, and Tin-Antimony-Silver Alloys, R. E. Leyman. No. 53 Technical Publication of the International Tin Research and Development Council.
International Index to Aeronautical Technical Reports, 1936. Society of British Aircraft Constructors.
The Hobson Master-Control System for Aircraft Engines (Fully Automatic).
The Air Navigation Regulations, 1937.
Modern Aeroplane and Seaplane Hangars, Dr.-Ing. Alfred Mehmel.
Grundlagen der Flugzeugnavigation, W. Immler.
Patents for Inventions, R. Haddan.
Notices to Aircraft Owners and Ground Engineers, 1920-1936.

Reports and Memoranda of the Aeronautical Research Committee:—
No. 1731. Plane Table Method of Measuring Take-Off and Landing Flight Paths, S. P. Osborne.
No. 1734. Full-Scale Tests of Hartshorn Ailerons on a Bulldog, A. E. Woodward Nutt.

No. 1736. Wind Tunnel Tests to Determine the Efficiency of an Airscrew Working in Front of a Thick Section Wing, D. W. Bottle and C. Callen.

No. 1751. A Study of the Flexural Axis Positions for Certain Box Sections, D. Williams and D. W. G. Fairbank.

No. 1756. The Distribution of Stress in Monocoque Wings, H. F. Winny.

No. 1757. A General Method of Calculating the Effect of Axial Constraint on Torsion on Different Forms of Two-Spar, Skin-Covered Wings, A. E. Russell.

No. 1762. The R.A.E. Mark Va Torsiograph, by The Staff of the Engine Experimental Department, R.A.E.

No. 1763. A Note on Roughness, S. Goldstein.

No. 1768. Some Experiments with Cascades of Aerofoils, A. R. Collar.

Kinematical Features of Depressions, A. H. R. Goldie. Geophysical Memoirs, No. 72, of the Meteorological Office.

LZ129, Hindenburg, Dr.-Ing. W. Von Langsdorff.

Aerodynamik Ein Gesamtwerk Über Das Fliegen, F. W. Lanchester. Translated from the English by Von C. und A. Runge.

Aérodynamique, F. W. Lanchester. Translated from the English by Commandant C. Benoit.

Aérodonétique, F. W. Lanchester. Translated from the English by Commandant C. Benoit.

J. LAURENCE PRITCHARD, *Secretary and Editor*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES
AUGUST, 1937

Telephones.

Will members please note that the Society has two telephone numbers, Regent 6800 and Regent 2736?

Society of British Aircraft Constructors Scholarships.

The Scholarship Selection Committee of the Society of British Aircraft Constructors and the Royal Aeronautical Society have made awards of Society of British Aircraft Constructors Scholarships to the following:—

Frederick Barnes, 12, Gretna Road, Coventry.
John Dickinson, 31, Prospect Terrace, Windlestone, Nr. Ferryhill, Co. Durham.
Barry Pemberton Laight, 14, The Circle, Birmingham, 17.
Roger William Miller, 27, Dornberg Road, Blackheath, S.E.3.
Roy Ernest Stainton, 5, The Crescent, Shortstown, Bedford.

The Scholarships are designed for the assistance of young men who are unable, for financial reasons, to take up a course of education fitting them to become aircraft engineers.

Candidates for scholarships had to be British Subjects between the ages of 16 and 18 on the 1st September in the year of the award.

A minimum of four scholarships a year of varying value up to a maximum value of £100 each per annum is awarded.

Scholarships are tenable with certain selected firms.

All holders of S.B.A.C. scholarships are expected to qualify for a technical grade in the Royal Aeronautical Society.

Entry forms and the general regulations for applying for one of these scholarships may be obtained from the Secretary.

Acknowledgments.

The Council gratefully acknowledge the gift of fourteen papers by Dr. F. W. Lanchester, Honorary Fellow, presented to the Library by the Author. These will be bound in one volume at a later date and will form a complete set of Dr. Lanchester's published works. A copy of "Aerodynamik, Volume II" has also been kindly presented by the Author.

The Council are grateful to Mr. Henry Hughes for so kindly presenting to the Society a copy of "Air Navigation" by Weems. A review of this book will appear in the review pages.

Robert Blair Fellowship.

A Robert Blair Research Fellowship has been awarded to Mr. H. Leaderman, B.Sc., for the Session 1937-1938. Mr. Leaderman intends spending a year at Massachusetts Institute of Technology studying the physical properties of metals

and reinforced synthetic resins. Mr. Leaderman was Honorary Secretary of the Students' Section in 1935-1936, and during his term of office the Section enjoyed the most successful Session since its inception.

Associate Fellowship and Associate Membership Examination.

The next examinations will be held in December, 1937. Entries must be in by September 30th, 1937.

Elliott Memorial Prize.

The Elliott Memorial Prize has been awarded to Sergeant/Apprentice W. Beringer, of Halton. The Elliott Memorial Prize, administrated by the Society, is awarded twice yearly to the apprentice at Halton who has the highest percentage of marks in the passing-out examination.

New Branches.

New Branches of the Society have recently been formed at Weybridge and the Isle of Wight, and the following officers have been appointed:—

Isle of Wight Branch.

President: Squadron-Leader C. J. W. Darwin, D.S.O., R.A.F. (Retd.).

Hon. Secretary: B. W. Townshend, Esq., A.C.G.I., A.M.I.Mech.E., A.F.R.Ae.S., Kite Hill Lodge, Wootton, Isle of Wight.

Weybridge Branch.

Chairman: F. Holliday, Esq., B.Sc.

Hon. Secretary: M. W. Wood, Esq., A.F.R.Ae.S., Vickers Works, Weybridge.

A Programme of lectures is being arranged by both Branches, and members living locally should get in touch with the Hon. Secretary for particulars.

Additions to the Library.

Technical Notes of the National Advisory Committee for Aeronautics:—

No. 592. A Study of the Factors Affecting the Range of Airplanes. David Biermann.

No. 593. Pressure Drop in Tubing in Aircraft Instrument Installations, by W. A. Wildhack.

No. 594. Tank Tests of Two Models of Flying Boat Hulls to Determine the Effect of Ventilating the Step. John R. Dawson.

No. 595. Bending Tests of Circular Cylinders of Corrugated Aluminium Alloy Sheet. Alfred S. Niles, John C. Buckwalter and Warren D. Reed.

No. 596. Full-Scale Wind Tunnel and Flight Tests of a Fairchild 22 Airplane Equipped with a Zap Flap and Zap Ailerons. C. H. Dearborn and H. A. Soule.

No. 597. Notes on the Calculation of the Minimum Horizontal Tail Surface for Airplanes Equipped with Wing Flaps. Harlet A. Soule.

No. 598. Wind Tunnel Tests of a Clark Y Wing with "Maxwell" Leading Edge Slots. William E. Gauvain.

Technical Reports of the N.A.C.A.:—

No. 585. Span Load Distribution for Tapered Wings with Partial-Span Flaps. H. A. Pearson.

No. 587. Blower Cooling of Finned Cylinders. Oscar W. Schey and Herman H. Ellerbrock, Jnr.

No. 588. Fuel Spray and Flame Formation in a Compression Ignition Engine Employing Air Flow. A. M. Rothrock and C. D. Waldron.

Publications Scientifiques et Techniques du Ministere de L'Air :—

No. 101. Étude Thermique de L'Oxydation Lente Des Carbures D'Hydrogène. Mlle. Suzanne Estradère.

No. 102. Étude de Silencieux Pour Moteurs D'Aviation. Docteur Yves Rocard et M. Jean Morlon.

No. 103. La Combustion Détonante dans les Moteurs a Explosion, Facteurs et Incidences D'Ordre Physique et Mecanique. M. Max Serruys.

Official Bulletin No. 24 of the International Commission for Air Navigation.

The Nautical Almanac and Astronomical Ephemeris for the Year 1938.

Résumé of Commercial Information Special Issue No. 4, 1937. Regular Air Transport Companies in Europe. Return Showing Details of Fleets in Operation as at 31st December, 1936. Issued by the Department of the Director-General of Civil Aviation.

Report and Memoranda No. 1755. Notes on Stubs for Seaplanes, by L. P. Coombes, B.Sc., and D. W. Bottle, B.Sc.

Empire Air Mail Scheme, Air Ministry and General Post Office.

Aerial Haze and its Effect on Photography from the Air, Monographs on the Theory of Photography, from the Research Laboratory of the Eastman Kodak Company.

The Phenological Report, 1936. Royal Meteorological Society.

Report of the Advisory Council for the Year 1936, Science Museum.

The War in the Air, Volume VI, by H. A. Jones.

The War in the Air, Appendices, by H. A. Jones.

Aerodynamik, Volume II, by F. W. Lanchester. Translated from the English by C. und A. Runge. (Presented by the Author.)

J. Laurence Pritchard, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES
SEPTEMBER, 1937

Telephones.

Will members please note that the Society has two telephone numbers, Regent 6800 and Regent 2736?

Lecture Programme 1937-1938.

The following lectures have at present been arranged for the Session, October, 1937—April, 1938. Further lectures are being arranged for the second half of the Session and will be announced later:—

1937.

October 14th.—"The Hafner Gyroplane." Herr R. Hafner.

October 21st.—"Practical Airscrew Performance." F. M. Thomas, Esq., A.F.R.Ae.S.

November 4th.—"Problems of High Speed Flight as Affected by Compressibility." C. N. H. Lock, Esq., M.A., F.R.Ae.S.

November 18th.—"The Take-off Problem in Modern Aircraft Design." H. F. Vessey, Esq., A.F.R.Ae.S.

December 2nd.—"Wing Surface Controls with Reference to Possible Developments in Flying Technique." Flt. Lieut. H. P. Fraser, A.F.C.

December 16th.—"Development of Sailplanes." Sqdn. Ldr. G. M. Buxton.

1938.

January 13th.—"The Practical Use of Radio as a Direct Aid to the Landing Approach in Low Visibility." Sqdn. Ldr. R. S. Blucke, A.F.C.

January 27th.—"Factors Controlling the Development of Electrical Ignition on Aero Engines." Dr. G. E. Bairsto, M.I.E.E., F.Inst.P.

February 3rd.—"Recent Research on the Development of the Aerodynamic Characteristics of Aircraft." E. F. Relf, Esq., F.R.S., F.R.Ae.S.

February 17th.—"The Maintenance of Civil Aircraft." H. L. Hall, Esq.

All lectures will be held in the Lecture Theatre of the **Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1,** by kind permission of the Council of the Institution, at 6.30 p.m. Light refreshments will be served between 6 and 6.30 p.m. Non-members will be admitted by ticket obtainable through a member of the Society.

Associate Fellowship and Associate Membership Examinations.

Candidates for the examinations in December, 1937, are reminded that entries must be received by the Secretary not later than September 30th. The examinations will be held on Wednesday and Thursday, December 8th and 9th.

Library.

The Library will be re-opened on Saturday afternoons on and from September 4th. The Library hours are 9.30—5 p.m. weekdays and 9.30—12.30 and 2—5 p.m. on Saturdays.

Will those members who have not returned books already due back kindly return them at once in order to assist with the checking of Library books.

Additions to the Library.

Reports and Memoranda of the Aeronautical Research Committee:—

No. 1699. Report on Puss Moth Accidents. Complete with Appendices.

No. 1771. Tests of Four Airscrew Sections in the Compressed Air Tunnel. D. H. Williams, A. F. Brown and E. Smyth.

No. 1772. Tests of R.A.F. 34 at Negative Incidences and of the Effect of Surface Roughness on R.A.F. 34 with Split Flap in the Compressed Air Tunnel. D. H. Williams and A. F. Brown.

No. 1773. Note on the Design of Corners in Duct Systems. G. N. Patterson.

No. 1735. Wind Tunnel Tests on Slotted Flaps on a Low Wing Monoplane: Flap Angle 0° to 90°. D. L. Ellis and M. B. Morgan.

Creep of Non-Ferrous Metals and Alloys. A Review of Published Information, by W. A. Baker, B.Sc.

The Properties of Lead and Lead Alloys. Summary Report on the Fatigue Resistance Lead and Lead Alloys, by H. Waterhouse.

Sky Pilot, by K. Langford Smith.

The Development of Sheet Metal Detail Fittings. William S. B. Townsend.

Luftfahrt-Forschung, Volumes 1 to 10.

By Order of the Shah, by "H.W." and Sidney Hay.

Public School Lectures.

The following is a list of lectures which have been prepared for delivery before Public Schools and other educational establishments. Each lecture is complete in itself and is illustrated by 40-50 slides and takes one hour to deliver:—

No. 1. The History of the Aeroplane.
No. 2. The Aeroplane and its Uses.
No. 3. Flying Boats and Seaplanes.
No. 4. Training R.A.F. Pilots.
*No. 5. How an Aeroplane is Made and Flies.
No. 6. A Trip into the Stratosphere.
No. 7. How an Aeroplane Flies.
No. 8. How an Aeroplane is Made.

* This lecture is a combination of Lectures 7 and 8 for those who want both together. Certain matter and slides given in Nos. 7 and 8 have been omitted so that the lecture takes no longer to deliver.

These lectures are available to any member who wishes to deliver a lecture and full particulars will be sent on application. The Society has a large collection of slides and a selection will be made, on request, on any particular aeronautical subject.

The Society arranges lectures before Public Schools and other educational establishments on request, and the Council will be grateful to any member who is willing to give one of these lectures when required.

List of Members.

The new List of Members will be published on January 1st, 1938. Will members who have any alterations they wish to make in their addresses,

designations, etc., kindly send in their corrections as soon as possible, as otherwise it will be assumed that their names, designations and addresses as now appearing in the List of Members are correct?

Forthcoming Events.

Saturday September 25th—

"Selection and Treatment of Steels for Aero Engines." Lecture by Miss Dorothy Spicer, A.R.Ae.S.I.

"Ice Formation on Aircraft in Flight," by Miss Pauline Gower.

Both lectures at 11 a.m., at Crosby Hall, Cheyne Walk, Chelsea, S.W.3, under the auspices of the Women's Engineering Society.

Members of the Society will be welcome.

J. LAURENCE PRITCHARD, *Secretary and Editor*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

OCTOBER, 1937

Conversazione and Garden Party, 1938.

The date of the Garden Party has been provisionally fixed for Sunday, May 8th, 1938, and for the Conversazione, Wednesday, January 19th, 1938.

Inaugural Lecture.

The Inaugural Lecture of the 1937-38 Session will be held on October 14th, 1937, at 6.30 p.m., when Herr R. Hafner will lecture on "The Hafner Gyroplane." The lecture will be held, by permission of the Council, in the Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. Light refreshments will be served from 6 p.m. to members free of charge. Visitors will only be admitted by ticket obtainable through a member of the Society. The chair will be taken by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.P., Past-President of the Society.

Council Meeting.

At a meeting of Council held on September 14th, 1937, the following members were elected:—

Fellow.—Alan Newell Clifton (from Associate Fellow).

Associate Fellows.—John Diedrich Ahlers, Philip Andrew Cooke, Hugh John Curnow, Reginald Edgar Gilbert Fulljames, Eric Grundy, Richard Manners Heldson, James Leonard Barnard Jones, John Parry Jones, Bernard Victor Leak, John Francis Xavier McKenna, John Richard Morgan, Norbert Edward Rowe, Cyril Hector Gibson Soper, Percival Nesbit Willoughby.

Associate Members.—Charles Rennie Paul Bizeray, Wilfred George Coombes, Caradoc Howell Evans, Joannes Jozef Granzier, Thomas Charles Hey, Jack Kenneth Woolgar Wheatley.

Associates.—Charles Leslie Best, Reginald Arthur Burton, John Alfred Choate, Charles Martyn Collard, Vincent Neville Dickinson, Eric Edwin Hedgcock, Albert Herbert William Kydd, Herbert Basil Goldwyer Michelmore, Charles Willard Miller, Joseph William Trevelyan, Victor Harold Wentworth, Esmond Birdsall Wilshire.

Graduates.—John Edgar Boast, Hugh Tempello Grigg, Hsueh-Chang Pang, George Maclaren Humphreys, Ralph Harry Price, Eric Raymond Staniland, Alan Frederick Walsh, Charles Harold Wigg.

Students.—Walter Henry Bewg, James Phipps Booth, Kenneth George Dunn, Allen Harold Claude Greenwood, Stewart Douglas Hall, Allan John Hancock, Douglas James How, Brian Ruckman Hutchinson, Harry Bertram Hallam Judd, Philip de Lacy Markham, Victor William John Prince, Norman Francis Rowe, George Smith, Kenneth John Spooner, Charles Roger Tennant, Jack Percival Thompson, Thomas Henry Whitehouse.

Companions.—Ronald Merriman Barry, Neil McLeod Gibson, Wallace Eric Locke, Alfred James Spilman.

Among the business discussed was the following:—Akroyd Stuart Memorial Prize; Report of the Finance Committee; Report of the Grading Committee; Appointment of Chairmen for the Lectures to be given in the first half of the Lecture Session; Appointment of Referees for the R.38 Memorial Prize Paper.

Professor J. C. Hunsaker.

Professor J. C. Hunsaker, of the Massachusetts Institute of Technology, will be visiting London from October 20th-26th and will be using this office as an address for correspondence. A dinner is being arranged to Professor Hunsaker during his visit.

Associate Fellowship and Associate Membership Examinations.

The next Associate Fellowship and Associate Membership Examinations will be held in the offices of the Society on Wednesday and Thursday, December 8th and 9th, 1937. The Library will be closed on both these days.

Library.

The Library has been re-opened on Saturday afternoons from September 4th. The Library hours are: 9.30-5 weekdays, and 9.30-12.30 and 2-5 on Saturdays.

List of Members.

The new List of Members will be published on January 1st, 1938. Will members who have any alterations they wish to make in their addresses, designations, etc., kindly send in their corrections as soon as possible.

General Discussion on Lubrication and Lubricants.

The Council of the Institution of Mechanical Engineers will hold a general discussion from Wednesday afternoon, October 13th, to Friday morning, October 15th, on lubrication and lubricants. A series of about 100 papers from leading world authorities will be presented. The discussion is being held in collaboration with a number of other Institutions and Societies, including the Royal Aeronautical Society.

Tickets of admission may be obtained from the Society, and must be applied for as soon as possible to avoid disappointment. The discussion is divided into four groups:—

Group I. Journal and thrust bearings.
Group II. Engine lubrication.
Group III. Industrial applications.
Group IV. Properties and testing.

Complete sets of advance copies of papers received in time for printing may be obtained for 3/- or for 2/6 in any group from the Secretary of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1.

Weybridge Branch.

Mr. R. K. Pierson, M.B.E., F.R.Ae.S., has accepted the Presidency of the Weybridge Branch.

Journals Wanted.

The Enoch Pratt Free Library, Baltimore, Maryland, is very anxious to complete its file of the Royal Aeronautical Society's Journal. Would anyone who wishes to dispose of any of the following get in touch with the Librarian direct? Vols. 27-31 (1923-1927).

Allied Airways.

Arrangements have been made with Allied Airways, Limited, for members of the Society, travelling by air between Great Britain and Norway, to receive a discount of 20 per cent.

Autogiro.

In the paper by M. Breguet in the September Journal the word "Autogiro" was used in a descriptive sense. The Cierva Autogiro Company Ltd., draw attention to the fact that the word autogiro is a Registered Trade Mark and may only be used in this sense.

Acknowledgments.

The Council gratefully acknowledge the gift of five guineas to the Endowment Fund from Messrs. Gale & Polden, Limited; a gift of a parcel of books, a number of Reports and Memorandum of the Aeronautical Research Committee and old photographs from Captain Gillman, Secretary of the Society of British Aircraft Constructors; a pamphlet "Experiments with Fluid Friction in Roughened Pipes," by C. F. Colebrook and C. M. White, from the authors; a copy of "Hungary from the Air," from Mr. E. Wieser, A.F.R.Ae.S.

Forthcoming Events.

October 6th.—Lecture before the Weybridge Branch by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

October 7th.—Lecture before the Portsmouth Branch by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

October 12th-14th.—Lilienthal-Gesellschaft fur Luftfahrtforschung Hauptversammlung, Munchen.

October 13th-15th.—General Discussion on Lubrication and Lubricants. Organised by the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1.

October 14th.—Lecture before the Society by Herr R. Hafner on "The Hafner Gyroplane," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, by kind permission of the Council, at 6.30 p.m.

October 19th.—Lecture before the Gloucester and Cheltenham Branch by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "A Trip into the Stratosphere."

October 21st.—Lecture before the Society by F. M. Thomas, Esq., A.F.R.Ae.S., on "Practical Airscrew Performance Calculations," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, by kind permission of the Council, at 6.30 p.m.

October 21st.—Lecture before Hendon Central Library by Mr. H. T. Winter on "Flight: Yesterday, To-day and To-morrow."

October 26th.—Lecture to the Scientific Society of Loughborough College by Captain J. L. Pritchard, Hon.F.R.Ae.S., on "Bird Flight in Its Relation to the Aeroplane."

November 4th.—Lecture before the Society by C. N. H. Lock, Esq., M.A., F.R.Ae.S., on "Problems of High Speed Flight as Affected by Com-

pressibility," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, by kind permission of the Council, at 6.30 p.m.

STUDENTS' SECTION.

September 30th.—Annual General Meeting in the Library of the Society at 7.30 p.m.

October 5th.—Inaugural Address by Lieut.-Colonel J. T. C. Moore-Brabazon, M.C., F.R.Ae.S., M.I.Ae.E., M.P., in the Library of the Society, at 7 p.m. The chair will be taken by Captain J. Laurence Pritchard, Hon. F.R.Ae.S.

October 23rd.—Visit to Irving Air Chutes of Great Britain, Limited, Letchworth, Herts, at 10.15 a.m.

October 26th.—Lecture, on " Detail Design," by Mr. E. Voss in the Library of the Society at 7 p.m. The chair will be taken by Professor G. T. R. Hill, M.C., M.Sc., F.R.Ae.S.

November 2nd.—Lecture on " Light Alloy Castings and Stampings for Aeronautical Purposes," by Mr. W. C. Devereux, F.R.Ae.S., in the Library of the Society at 7 p.m. The chair will be taken by Professor F. T. Hill, F.R.Ae.S., M.I.Ae.E.

November 5th.—Informal Supper.

Additions to the Library.

Technical Report of the Aeronautical Research Committee, 1935-36. Vol. I Aerodynamics; Vol. II Structures, Flutter, Engines, Sailplanes, etc.

Engineering Data—Resistance Welding Theory and Practice. Published by P. R. Mallory & Co. Inc. Two copies.

Petrol-Engined Model Aeroplanes. C. E. Bowden.

Die Deutsche Luftfahrt Jahrbuch 1937. Dr. H. Orlovius und Ing. R. Schulz.

Famous Aircraft. H. Coble and A. R. Payne.

Hydro and Aerodynamics. S. L. Green.

The Design and Construction of Flying Model Aircraft. D. A. Russell.

The Mechanics of Turbulent Flow. Boris A. Bakhmeteff.

Nineteenth Annual Report of the National Research Council, 1935-1936.

Experiments with Fluid Friction in Roughened Pipes by C. F. Colebrook and C. M. White. Reprinted from Proceedings of the Royal Society of London.

The Lindberghs. P. J. O'Brien.

Handbook of Aeronautics. Part I. Aerodynamics. E. F. Relf.

Seaplanes. D. J. Brimm, Jnr.

" Hungary from the Air," by V. Bierbauer.

Technical Publications of the International Tin Research and Development Council:—

Series A, No. 57, Mechanical Properties of some White Bearing Metals and other Tin-Base Alloys at Various Temperatures, by C. E. Homer and H. Plummer.

Series A, No. 58, The Tensile Properties of a Series of White-Metal Bearing Alloys at Elevated Temperatures, by H. Greenwood.

Series B, No. 5, Fusible Alloys containing Tin, by E. J. Daniels.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

NOVEMBER, 1937

Council Meeting.

A Meeting of the Council was held in the Offices of the Society on Tuesday, October 19th, 1937.

Present: Mr. A. H. R. Fedden (Vice-President) in the chair; Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. H. Hall, Professor F. T. Hill, Major D. H. Kennedy (Honorary Treasurer), Lieut.-Colonel J. T. C. Moore-Brabazon (Past-President), Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard, Mr. D. R. Pye (Vice-President) and Mr. L. A. Wingfield (Solicitor).

Among the business discussed was the following:—Appointment of official representatives of the Society at the Fifth International Congress for Applied Mechanics at Massachusetts; Report of the Finance Committee; Report of the Grading Committee; Report of the Medals and Awards Committee; Letter from the Decimal Association; Letter from the Institute of Aeronautical Sciences; Garden Party in May, 1938, and Conversazione in January, 1938; Letter from the Students' and Graduates' Section.

Elections.

The following members were elected at the Meeting of Council held on October 19th, 1937:—

Fellow.—James Douglas Haddon (from Associate Fellow).

Member.—Charles William Ernest Browse (from Associate Member).

Associate Fellows.—Arthur Beavan, Thomas Stanley Davies Collins, Alex Arthur Fletcher, Jack Hanson, Cecil Reuben Hall Johnson, Neville Durrant New, Leslie Rendall Parkinson, John Henry Payne, Alfred Grenvile Pugsley, Glyndwr Rees, Frederick William Victor Webber.

Associate Members.—Glyn Ashfield, Arthur MacHiven Brown, William Howarth Downey.

Associates.—Oscar Reginald Rowe, Victor William Steele, John Wimperis.

Graduates.—Geoffrey Dean Dawson, Ian Gair Duncan, Kenneth Calvert Hales, Ernest Rose, Lokusatu Heva Sumanadasa.

Students.—Peter Charles Armour, Laurence Sydney Edwards, John Roy Ewans, Guy Clavell Inge Gardiner, Trevor Harold Gilbert, Donald Hill, John Hawke Horsfield, Ronald Samuel Hughes, David William Kew, Godfrey Henry Lee, David Basil Gerald Miles, Anthony Basil Pippet, Sidney James Pope, David Harry Robbins, Henry Roberts, Frank Desmond St. Hilaire, Vivian Egerton Saunders, Leonard Smith, Walter John Revill Stocks, Cyril Ernest Weeden, Kenneth Grahame Wilkinson.

Society's Diary.

A special pocket diary has been prepared for members. It is bound in limp dark blue leather, with the badge of the Society on the cover and contains a wallet for notes, stamps and cards and a separate booklet "Aviators Information."

The number of these diaries which will be printed is strictly limited. They will be ready at the end of November and orders for the diaries should be given now, as it will not be possible to repeat them once the limited stock is exhausted.

The price of the diary is 3s. 6d. post free.

Brancker Memorial Lecture.

The Brancker Memorial Lecture, under the auspices of the Institute of Transport, will be given this year by Lord Sempill, A.F.C., F.R.Ae.S., on "Civil Aviation as a World Force." The lecture will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, on Tuesday, November 16th, at 6 p.m. Admission is free without ticket.

Akroyd Stuart Memorial Prize.

The Akroyd Stuart Memorial Prize is a prize founded under the will of the late Herbert Akroyd Stuart for a paper dealing with the origin and development of heavy oil engines. The prize, which is worth approximately 45 guineas, is awarded at the discretion of the Council every two years. Entries for the next award should be made by June 30th, 1938, and three typed copies should be submitted. The Council will consider papers for the award which deal with any aspect of the development of the heavy oil engine.

Royal Aero Club Dinners After Lectures.

As in previous years, the Royal Aero Club are arranging a late dinner for those who attend lectures of the Society. These dinners have been fixed at 2s. 6d. and members of the Society will be made honorary members of the Royal Aero Club for those evenings. It is hoped that as many members of the Society as possible will take advantage of the facilities offered by the Royal Aero Club, whose address is 119, Piccadilly, W.1. Telephone: Grosvenor 1246-7-8.

List of Members.

The List of Members published on January 1st, 1938, is now in course of preparation. Will members who have any alterations they wish to make in their addresses, designations, etc., kindly send in their corrections as soon as possible, as otherwise it will be assumed that their names, designations and addresses as now appearing in the List of Members are correct.

Acknowledgments.

The Council gratefully acknowledge the gift of historical pamphlets and books from Lieut.-Colonel F. A. G. Noel, a founder member of the Royal Aero Club; the gift of N.A.C.A. Reports and Reports and Memoranda from the Society of British Aircraft Constructors; and the gift of a slide of the 50 h.p. Antoinette engine from the Director of the Science Museum, Lieut.-Colonel E. E. B. Mackintosh. The Council particularly wish to thank Mr. R. L. Carter, *Associate*, for the gift of an up-to-date lantern to the Library, to replace the one which has outlived its usefulness.

Fifth International Congress for Applied Mathematics.

Members of the Society who wish to attend the above Congress should communicate with the Secretary, Professor J. C. Hunsaker, Hon. F.R.Ae.S., Massachusetts Institute of Technology, Cambridge, Massachusetts. The Congress is a meeting of individuals interested in Applied Mechanics and any

such person is invited to become a member upon registration and payment of the Congress fee of $5.00. Full particulars may be obtained from Professor Hunsaker.

Additions to the Library.

Report of the XIIth International Acetylene Congress, Volumes I-VI.
Axial Flow Fans. The Theory and Performance of, by Curt Keller, Lionel S. Marks and John R. Weeke.
LZ. 129 " Hindenburg," by Dr. Ing. W. Lansdorff.
I Wanted Wings, by Beirne Lay.
The Fine Structure of Matter, by C. H. Douglas Clark.
Thermodynamic Properties of Steam, Joseph H. Keenan and Frederick G. Keyes.
Aerial Photographs. Characteristics and Military Applications, by Dache M. Reeves.
Aviation. Its Commercial and Financial Aspects, by Richard Rea Bennett.
Airports and Airways. Cost, Operation and Maintenance, by Donald Duke.
Wings. My 25 Years of Flying, by H. C. Biard.
Gran Chaco Adventure, by T. Wewege-Smith.
The Next War, by L. E. O. Charlton.
Aircraft of the British Empire, 1937, Leonard Bridgman.
Machine Drawing for Students, by F. J. Pryer. (2nd Edition.)
National Defence. The Royal Air Force. Air Vice-Marshal E. L. Gossage.
The Air Almanac. H.M. Nautical Almanac Office.
Der Mensch Fliegt, by Paul Karlson.
Commercial Air Transport (Extract from the South African Journal of Economics), by E. D. Weiss.

Publications Scientifiques et Techniques du Ministere de L'Air :—

No. 104. Procédé Pratique de Mesure Précise de la Vitesse de Diffusion des Gaz a Travers les Membranes, by Ch. Ledoux.
No. 105. Application de L'Analyse Spectrographique a L'Étude des Alliages, by Henri Triche.
No. 106. Photoélasticimetrie et Apsidométrie, by H. L. Supper.
No. 107. Action des Basses Températures Recontrées en Photographie Aerienne sur la Sensibilité des Émulsions, by Maurice Roulleau.

Scientific Notes, India Meteorological Department :—

Vol. VII, No. 72. Normal Monthly Percentage Frequencies of Surface and Upper Winds up to 3 km. at Allahabad, Begumpet, Delhi, Sambalpur, Sandoway, Silchar and Victoria Point.
Vol. VII, No. 73. Daily Variations of Temperature and Pressure at Different Levels over Agra Associated with Passage of Western Disturbances.

Publications of the Guggenheim Aeronautics Laboratory, California Institute of Technology :—

No. 81. On the Results of Aerodynamic Research and Their Application to Aircraft Construction, Clark B. Millikan.
No. 82. The Physicist Gets Air-Minded, Clark B. Millikan.
No. 83. On the Statistical Theory of Turbulence, Th. Von. Kármán.
No. 84. The Fundamentals of the Statistical Theory of Turbulence. Th. Von Kármán.
No. 85. Le Transport Aerien A Haute Altitude, W. G. Rockefeller and Norton B. Moore. (Journal Tech. Internationale Aeronautique.)

No. 86. The Theory for Rectangular Wings of Small Aspect Ratio, William Bolley.

No. 88. Stress Distribution in Stiffened Panels under Compression, E. E. Sechler.

Number of Registered Civil Aircraft. Résumé of Commercial Information. Special Issue No. 5, 1937. Department of the Director-General of Civil Aviation, Air Ministry.

Monthly Frequency Tables for January, 1937. Director-General of Observatories.

Decouverte d'un Second Mouvement de Revolution de la Terre sur elle-meme, Jean Barles.

The Thompson Trophy Race. Record of Machines and Pilots, 1930-1937.

Zeppelin, by Captain Ernst A. Lehmann.

Magnesium and its Alloys, J. L. Haughton and W. E. Prytherch.

The Brown-Firth Research Laboratories (Descriptive Booklet).

The Germs and Development of Some Mechanical Inventions, by C. F. Dendy Marshall.

Wunder Des Möwenfluges, by W. Schack, Dr. Leege and Prof. Focke.

Aeronautic Radio. Aeronautics Bulletin No. 7, U.S. Department of Commerce.

Civil Aeronautics in the United States. Aeronautics Bulletin No. 1, U.S. Department of Commerce.

Copper and its Alloys in Automobile Design, by D. P. C. Neave.

Jim Mollison, Playboy of the Air. James Mollison.

Handbook of Aeronautics, Part II, Performance, by R. N. Liptrot.

Kunstoff-Wegweiser, Von Dr. G. Kranzlein und Dr. L. Lepsius.

Leichte Dampfantriebe, an Land, zur see, In der Luft, by Frederich Münzinger.

German Copper and Brass Welding Practice. (Translated from the German "Das Schweissen von Kupfer und Messing," Deutsches Kupfer Institut, Berlin.)

Gothaer Waggonfabrik AG. Gotha.

Forthcoming Events.

November 2nd.—Lecture before the Isle of Wight Branch, by H. J. Pollard, Esq., F.R.Ae.S., on "Metal Aircraft Production."

November 3rd.—Lecture before the Weybridge Branch, by Flt. Lieut. P. W. S. Bulman, M.C., A.F.C., F.R.Ae.S.

November 4th.—Lecture before the Society, by C. H. N. Lock, Esq., M.A., F.R.Ae.S., on "Problems of High Speed Flight as Affected by Compressibility," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1 (by kind permission of the Council).

November 8th.—Lecture before the Westbury Branch of the British Legion, by Captain F. S. Barnwell, F.R.Ae.S., on "The History of the Aeroplane."

November 11th.—Lecture before the Portsmouth Branch, by Lieut.-Col. W. Miles, on "The Application of Wireless to Civil Aviation."

November 11th.—Lecture before the Yeovil Branch, by Squadron Leader Hopkins, R.A.F., on "A Survey of Aircraft Armament."'

November 12th.—Joint Meeting with the Coventry Branch and the Coventry Engineering Society, by A. Swan, Esq., B.Sc., A.M.Inst.C.E., A.F.R.Ae.S., on "Compression Ignition Aero Engines."

November 16th.—Lecture before the Isle of Wight Branch, by W. Hackett, Esq., on "Manufacture and Manipulation of Steel Tubes."

November 17th.—Lecture before the Weybridge Branch, by W. C. Devereux, Esq., F.R.Ae.S., on "Light Alloy Castings and Stampings for Aeronautical Purposes."

November 18th.—Lecture before the Society, by H. F. Vessey, Esq., A.F.R.Ae.S., on "Wing Loading and the Take-off Problem," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, at 6.30 p.m. (by kind permission of the Council).

November 22nd.—Lecture before the Halton Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Bird Flight in Relation to Aeronautical Engineering."

November 25th.—Lecture before the Yeovil Branch, by a Representative of Imperial Airways, on "Air Services."

November 25th.—Lecture before the Portsmouth Branch, by Commander R. R. Graham, A.F.R.Ae.S., R.N., on "Some Aspects of the Flight of Birds."

November 25th.—Lecture before the Coventry Branch, by Dr. R. C. Sutcliffe, on "Clouds and Their Formation, Structure and Associated Flying Conditions."

November 26th.—Lecture before the Foremen's Mutual Benefit Society, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Recent Progress in Aircraft."

November 30th.—Lecture before the Bristol Branch, by Captain J. Laurence Pritchard, Hon. F.R.Ae.S., on "Bird Flight."

November 30th.—Lecture before the Isle of Wight Branch, by E. Relf, Esq., A.R.C.Sc., F.R.Ae.S., on "Aeronautical Research Methods."

December 1st.—Lecture before the Weybridge Branch, by Dr. H. Roxbee Cox, Ph.D., D.I.C., B.Sc., F.R.Ae.S., on "Large Aeroplanes."

December 2nd.—Lecture before the Society, by Squadron Leader H. P. Fraser, A.F.C., B.A., A.F.R.Ae.S., on "High Wing Loading and Some of its Problems from the Pilot's Point of View," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, at 6.30 p.m. (by kind permission of the Council).

December 9th.—Lecture before the Portsmouth Branch, by Captain F. Entwistle, on "Meteorology and Aviation."

December 9th.—Lecture before the Yeovil Branch, by Squadron Leader F. F. Garraway, O.B.E., on "Organisation and Duties of the Royal Air Force."

December 15th.—Lecture before the Weybridge Branch, by J. Donaldson Craig, Esq., on "Anodic Treatment."

December 16th.—Lecture before the Society, by Squadron Leader G. M. Buxton, R.A.F., on "Development of Sailplanes," in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, at 6.30 p.m. (by kind permission of the Council).

December 16th.—Coventry Branch. Short papers to be read by Branch Members, followed by discussions.

December 16th.—Lecture before the Isle of Wight Branch, by G. H. Dowty, Esq., M.I.Ae.E., A.F.R.Ae.S., on "Hydraulic Services in Aircraft."

STUDENTS' SECTION.

November 2nd.—Lecture on "Light Alloy Castings and Stampings for Aeronautical Purposes," by W. C. Devereux, Esq., F.R.Ae.S., in the Library of the Society, at 7 p.m. The chair will be taken by Professor F. T. Hill, F.R.Ae.S., M.I.Ae.E.

November 5th.—Informal Supper at the Royal Aero Club, 119, Piccadilly, W.1, at 7.30 p.m. Tickets to be obtained from P. Masefield, Esq., c/o *The Aeroplane*, 175, Piccadilly, W.1, or from Members of the Committee and Representatives.

November 13th.—Visit to the Works of the de Havilland Aircraft Company, Hatfield, Herts, at 2.30 p.m. Names to be sent in to the Honorary Secretary of the Students' Section by November 8th.

November 16th.—Lecture on "The Mechanical Aspect of Wing Flutter Problems," by P. B. Walker, Esq., M.A., Ph.D., A.F.R.Ae.S. The chair will be taken by H. Roxbee Cox, Esq., Ph.D., D.I.C., F.R.Ae.S.

December 9th.—Joint Meeting with the Institution of Petroleum Technologists, Students' Section, and the Institution of Automobile Engineers, Graduate Grade, on "Torsional Vibration in Engines," by R. J. W. Cousins, Esq., in the Library of the Society, at 7 p.m.

December 11th.—Visit to the Works of High Duty Alloys, Limited, Slough, Bucks, at 3 p.m. Names to be sent in to the Honorary Secretary of the Students' Section by December 6th.

J. LAURENCE PRITCHARD, *Secretary and Editor.*

THE

ROYAL AERONAUTICAL SOCIETY

With which is incorporated the Institution of Aeronautical Engineers

MONTHLY NOTICES

DECEMBER, 1937

Christmas Holidays.

The Offices and Library of the Society will be closed from Friday noon, December 24th, and will be re-opened on Tuesday, December 28th.

Lecture Programme—Second Half 1937-1938 Session.

Jan. 13th.—" The Practical Use of Radio as a Direct Aid to the Landing Approach in Low Visibility." Squadron Leader R. S. Blucke, A.F.C.

Feb. 3rd.—" Recent Research on the Development of the Aerodynamic Characteristics of Aircraft." E. F. Relf, Esq., F.R.S., F.R.Ae.S.

Feb. 17th.—" The Maintenance of Civil Aircraft." H. L. Hall, Esq.

April 7th.—" The Manipulation of the Boundary Layer." E. G. Richardson, Esq., B.A., D.Sc., Ph.D.

April 21st.—" Factors Controlling the Development of Electrical Ignition on Aero Engines." Dr. G. E. Bairsto, M.I.E.E., F.Inst.P.

May —.—Wilbur Wright Lecture.

Further lectures to be announced later.

All lectures will be held in the Lecture Theatre of the *Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1*, at 6.30 p.m., by kind permission of the Council of the Institution. Light refreshments will be served between 6.0 and 6.30 p.m. Non-members will be admitted by ticket obtainable through a member of the Society.

Reception, January 19th, 1938.

On Wednesday, January 19th, 1938, the Council will hold a Reception at the Science Museum, South Kensington, to mark the 72nd anniversary of the foundation of the Society. Particulars will be sent to all members shortly. Members are reminded that this Reception is a separate function from the Wilbur Wright Lecture which will be given in May, 1938.

Council Meeting.

A Meeting of the Council was held in the Offices of the Society on Tuesday, November 9th, 1937.

Present: Mr. F. Handley Page (Vice-President) in the chair; Major G. P. Bulman, Mr. H. Roxbee Cox, Mr. A. H. R. Fedden (Vice-President), Mr. A. Gouge, Mr. A. H. Hall (Vice-President), Professor G. T. R. Hill, Major D. H. Kennedy (Honorary Treasurer), Mr. W. O. Manning, Lieut.-Col. W. Lockwood Marsh, Dr. N. A. V. Piercy, Professor A. J. Sutton Pippard.

Among the business discussed was the following:—The Fifth International Congress for Applied Mechanics at Massachusetts; Report of the Medals and Awards Committee; Report of the Finance Committee; Report of the Grading Committee; Report of the Development Committee; and Correspondence with the Institute of Aeronautical Sciences.

Mr. W. C. Devereux, Fellow, has been co-opted on the Council in place of the late Mr. R. J. Mitchell.

Election of Members.

The following members were elected at the Council Meeting on November 9th, 1937:—

Associate Fellows.—Bruce McArthur Foster, Clifford John Price, John Benjamin Brynmar Owen, Henry Phillips, Thomas Rowntree.

Associate Members.—Roy Champion Kean, Arthur Vicary Hunter.

Associates.—John Roy Cotton, Walter Frederick Locke.

Graduates.—Alfred Herbert Aylwin Bastable, George Henry Macmillan Birkbeck, Ralph Cuthbert Chisholm Brown, David Ketchen Marshall, John George Magrath Pardoe, Edgar Allen Stroud.

Students.—John Edwards Adamson, Francis Stanley Burt, Harin Daniel Tabakman, George Steedman Hislop, Robin Piercy, Thomas David Weston Ross.

Companion.—Caspar John.

Elliott Memorial Prize.

The Elliott Memorial Prize has been awarded to Aircraft Apprentice R. Battersby. This prize is awarded twice yearly to the apprentice at Halton who has the highest percentage of marks in the passing-out examination.

Society's Diary.

A special pocket diary has been prepared for members. It is bound in limp dark blue leather, with the badge of the Society on the cover and contains a wallet for notes, stamps and cards, and a separate booklet "Aviators' Information."

The number of these diaries which will be printed is limited. Orders for the diary should be given now, as it will not be possible to repeat them once the limited stock is exhausted.

The price of the diary is 3s. 6d., post free.

Endowment Fund.

The Council acknowledge with grateful thanks the gift of 10 shillings to the Endowment Fund from Flight Sergeant J. V Saunders, Associate Member. This is the third donation from Mr. Saunders and his generosity is appreciated.

Additions to the Library.

Report of the Annual General Meeting of Imperial Airways, 1937.

Résumé of Commercial Information. Series 8, No. 2, May-July, 1937. With Appendix "A"—U.S.A. Progress of Civil Aeronautics, 1926-1936, and Appendix "B"—Gliding Activities during 1936.

Résumé of Commercial Information. Special Issue No. 6, 1937. Number of Registered Civil Aircraft.

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No. 1770. The Behaviour of a Pitot Tube in a Transverse Total-Pressure Gradient, A. D. Young and J. N. Maas.

No. 1775. The Experimental Determination of the Bending Actions Induced by Axial End Constraints in a Rectangular Tube in Torsion, D. Williams and C. B. Smith.

No. 1776. Note on the Directional Stability of Seaplanes on the Water, J. P. Gott.

No. 1777. Effect of Differences of Form on the Porpoising Characteristics of Two Flying Boats, L. Johnston and W. D. Tye.

No. 1778. Note on the Standardisation of Pitot-Static Head Position on Monoplanes, S. B. Gates and J. Cohen.

No. 1780. Diffusion of Concentrated Loads into Monocoque Structures, H. L. Cox, H. E. Smith and C. G. Conway.

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No. 594. Characteristics of Six Propellers, including the High-Speed Range, T. Theodorsen, M. J. Brevoort and G. W. Stickle.

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No. 594. Full-Scale Tests of a New Type N.A.C.A. Nose-Slot Cowling, T. Theodorsen, M. J. Brevoort, G. W. Stickle and M. N. Gough.

No. 596. Cooling Tests of a Single-Row Radial Engine with Several N.A.C.A. Cowlings, M. J. Brevoort, G. W. Stickle and Herman H. Ellerbrock, Jnr.

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No. 606. Empirical Corrections to the Span Load Distribution at the Tip, H. A. Pearson.

No. 607. The Behaviour of Thin-Walled Monocoque Cylinders under Torsional Vibration, Robert E. Pekelsma.

Twenty-second Annual Report of the National Advisory Committee for Aeronautics (Reports Nos. 542-576).

Duralumin and its Treatment, P. Litherland Teed.

Methods of Bending Wood by Hand, Forest Products Research.

The Treatment of Problems in Engineering by Dimensional Theory, F. W. Lanchester.

The Menace of the Clouds, L. E. O. Charlton.

Metallurgical Abstracts, General and Non-Ferrous, Institute of Metals.

High Speed Diesel Engines (3rd Edition), Arthur W. Judge.

Transactions of the Institute of Naval Architects, Volume LXXIX.

Aero and Auto Engine Facts and Data, H. R. Langman.

Steels for the User, R. T. Rolfe.

Abstracts of Dissertations Approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge.

The German Air Raids on Great Britain 1914-1918, Joseph Morris.

Freelance Pilot, Norman Macmillan.

Aerofoil Calibration Tests in the Tsing Hua 5-foot Wind Tunnel, K. L. Feng.

Aviation. A Story of the Conquest of the Air, Ernest E. Walker.

Metallography (4th Edition), C. H. Desch.

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Das Buch der Deutschen Fluggeschichte:—

Volume I—Vorzeit, Wendezeit, Werdezeit, Peter Supf.

Volume II—Vorkreigszeit, Kriegszeit, Nachkriegszeit, Peter Supf.

The Internal Combustion Engine, Volume I (Second Edition), D. R. Pye.

With the Italia to the North Pole, Umberto Nobile. (Translated from the Italian by Frank Fleetwood.)

Synoptic and Aeronautical Meteorology, Horace Robert Byers.

Ice Accretion on Aircraft. Meteorological Professional Notes No. 8. Dr. G. C. Simpson.

Analysis of Stress in Thin-Walled Concrete Tubes, F. L. Wattendorf and C. C. Chang.

The First Glider Made in China, K. L. Feng.

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Publications Scientifiques et Techniques du Ministere de L'Air :—

No. 108. Recherches sur L'Amelioration des Qualites Aerodynamiques des Profils D'Ailes aux Grandes Vitesses, D. Riabouchinsky.

No. 109. Recherche de la Forme D'Equilibre de deux Tourbillons Cylindriques de Densite Uniforme et de Section Finie en Rotation Uniforme L'un Par Rapport a L'Autre dans un Fluide non Visqueux, J. Rossignol.

No. 110. Resistance des Spheres en Mouvement Accelere dans un Fluide, Jean Daniel Vagner.

Forthcoming Events.

Dec. 2nd.—Lecture before the Society by Squadron Leader H. P. Fraser, A.F.C., on " High Wing Loadings and Some of its Problems from the Pilot's Point of View."

Dec. 16th.—Lecture before the Society by Squadron Leader G. M. Buxton, on " Development of Sailplanes."

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Jan. 13th.—Lecture before the Society by Squadron Leader R. S. Blucke, A.F.C., on " The Practical Use of Radio as a Direct Aid to the Landing Approach in Low Visibility."

Jan. 19th.—Reception at the Science Museum, South Kensington, S.W.7.

The Society's Lectures are held in the Lecture Hall of the Institution of Mechanical Engineers at 6.30 p.m. (by kind permission of the Council). Refreshments are supplied from 6.0 until 6.30 p.m. before each lecture.

STUDENTS' SECTION.

Dec. 9th.—Joint Meeting with the Institution of Petroleum Technologists (Students' Section) and the Institution of Automobile Engineers (Graduate Grade). Lecture: " Torsional Vibration in Engines," R. J. W. Cousins.

Dec. 11th.—Works Visit: High Duty Alloys, Limited, Slough, Buckinghamshire, at 3.0 p.m. (Names to be sent in by December 6th.)

Dec. 21st.—Lecture: " Control Surface Design," A. F. Walsh, B.Sc., Grad.R.Ae.S.I.

The Lectures before the Students' Section are held in the Library at 7, Albemarle Street, W.1, at 7 p.m. Refreshments are supplied from 6.15 p.m.

BRANCHES.

Dec. 1st.—*Southampton Branch*: " Aerodynamic Research at the N.P.L.," by Mr. E. F. Relf, F.R.S., F.R.Ae.S.

Dec. 1st.—*Weybridge Branch*: " Large Aeroplanes," Dr. H. Roxbee Cox, B.Sc., D.I.C., F.R.Ae.S.

Dec. 9th.—*Portsmouth Branch*: " Meteorology and Aviation," Capt. F. Entwistle.

Dec. 9th.—*Yeovil Branch*: " Organisation and Duties of the Royal Air Force," Squadron Leader F. F. Garraway, O.B.E.

Dec. 14th.—*Gloucester and Cheltenham Branch*: " Test Flying," Mr. P. E. G. Sayer.

Dec. 15th.—*Weybridge Branch*: " Anodic Treatment," Mr. J. Donaldson Craig.

Dec. 16th.—*Isle of Wight Branch*: " Hydraulic Services in Aircraft," Mr. G. H. Dowty, F.R.Ae.S.

Dec. 16th.—*Coventry Branch*: Short papers to be read by Branch Members, followed by discussions.

Dec. 30th.—*Yeovil Branch*: " Gliding and Soaring," Hugh Bergel.

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Jan. 5th.—*Southampton Branch*: " Aircraft Productions," by H. J. Pollard, F.R.Ae.S.

Jan. 13th.—*Yeovil Branch*: " Aero Engine Design," a Representative of de Havillands.

Jan. 20th.—*Portsmouth Branch*: " Aircraft of the Future," Mr. A. Hessell Tiltman, F.R.Ae.S.

Jan. 20th.—*Coventry Branch*: " The Installation of Aero Engines," Dr. G. P. Douglas, M.C., A.F.R.Ae.S.

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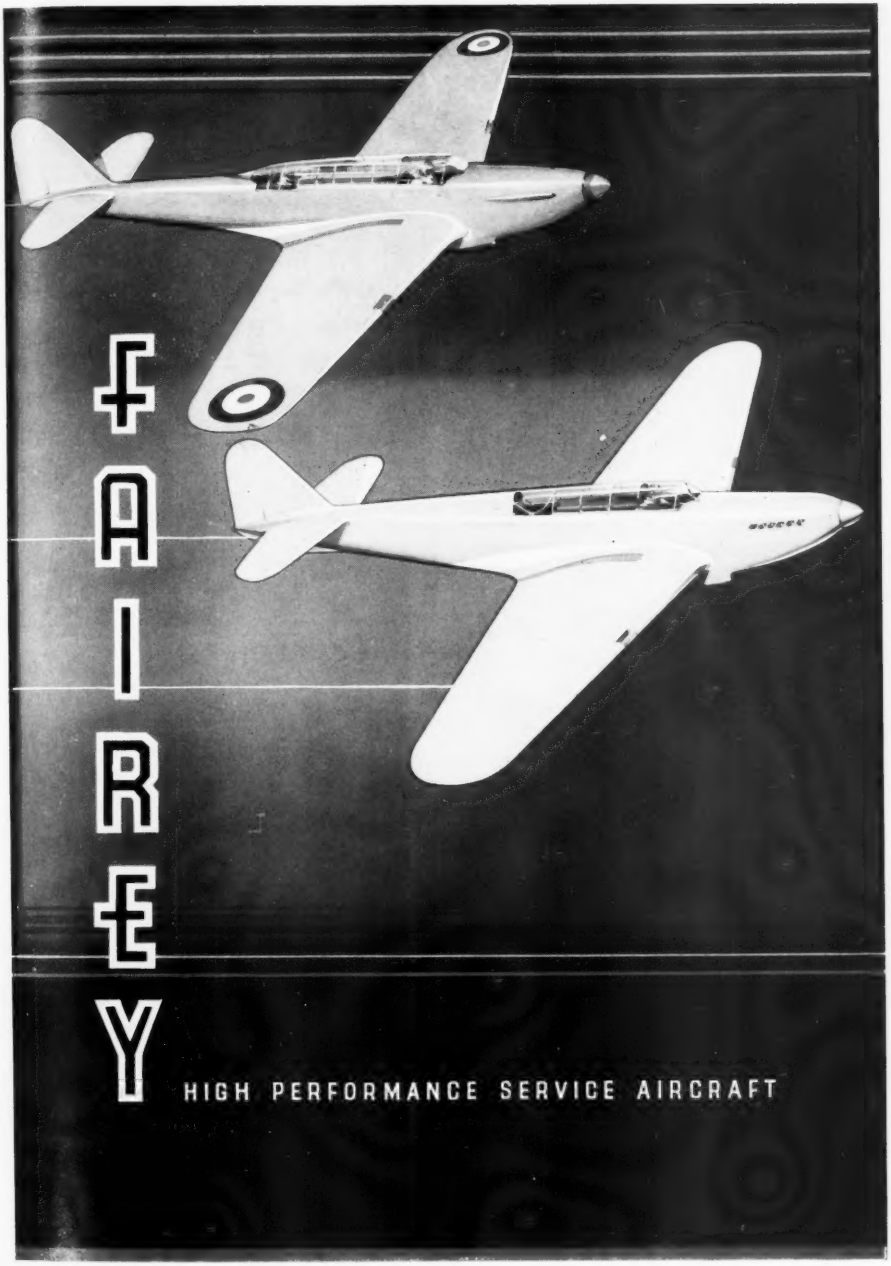
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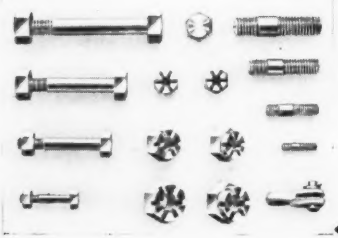

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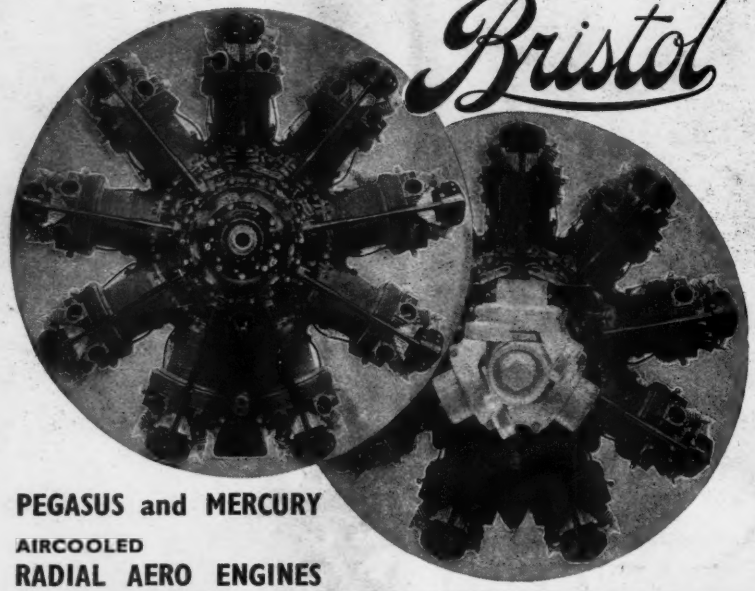

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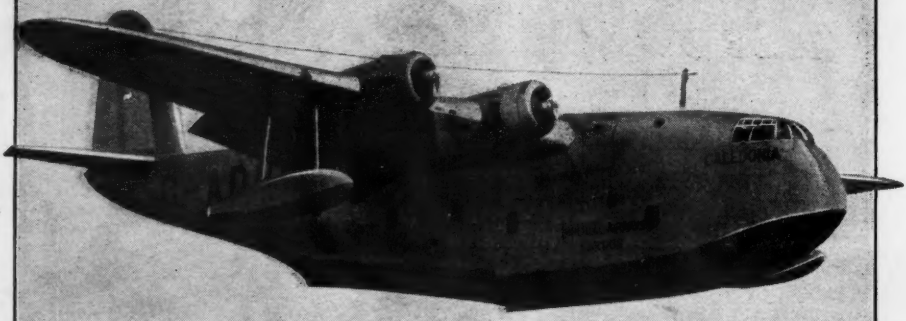

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